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Exploring the Non-Randomness of Human Spatial Choice Behavior: Generating a Database for Tactical AI

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Abstract

It has been determined in basic psychological research that humans have preferences for certain numbers, sequences, and locations. In the current study we examine whether people understand this preference information, either explicitly or implicitly. 547 participants were presented with 4 shapes (approximately half of the sample completed the study on paper, the other half via the internet). For each shape they were asked to select: 1. Any location within the shape, 2. The location you believe others are most likely to select, and 3. The location you believe others are least likely to select. Individuals were successful at predicting the locations others were likely to select, demonstrating an awareness of the nature of non-random behavior. However, individuals failed to accurately select the locations others were least likely to select. The applications of these findings are discussed.

Résumé

Les recherches fondamentales en psychologie ont démontré que les êtres humains accordent la préférence à certains chiffres, à certaines séquences et à certains emplacements. Dans cette étude, nous cherchons à savoir si les gens comprennent ces renseignements sur les préférences, de manière explicite ou implicite. On a présenté quatre figures à 547 participants (environ la moitié des répondants ont indiqué leurs choix sur papier et l'autre par le biais d'Internet). Pour chacune des formes, on leur a demandé de choisir : 1. n'importe quel emplacement dans la figure, 2. l'emplacement qu'ils pensaient que les autres seraient le plus portés à choisir et 3. l'emplacement qu'ils pensaient que les autres seraient le moins portés à choisir. Les participants ont réussi à prévoir les emplacements que les autres seraient portés à choisir, ce qui montre qu'ils sont sensibles à la nature du comportement non aléatoire. Les participants n'ont toutefois pas réussi à prévoir les emplacements qui seraient le moins souvent choisis. On discute des applications de ces constatations.

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Executive summary

Background

It is generally well-known that individuals tend not to exhibit random behaviour. Despite scientific studies showing this, there has never been a concerted effort to establish whether people use this information or even know whether it is true about other individuals. If the individual understands the non random behaviour at some level by making accurate choices when asked how other people would behave then one can extrapolate whole new ways of thinking about individual intelligence as we interact with fellow human beings. In the present study, subjects will be asked to place a mark within a shape situated on a piece of paper (or click in the shape on a video screen for the internet version of the task). They will first be presented with a neutral condition ("place an x anywhere in the shape"), then asked to place an x where others are most likely to place their x, and finally asked to place an x where others are least likely to place their x.

Results

A study of location selection in a variety of shapes revealed that people know the nature of non random behaviour, by successfully finding the locations most commonly picked by others, and avoiding those locations if asked to do so. However, individuals failed at selecting the location least commonly picked. That is, there were locations where few of the respondents picked regardless of the condition of the study. The applications of these findings are discussed.

Significance

Psychologists seek ultimately to understand the mind. But, this must be extrapolated from the observation of behaviour. Typically, that is either in a controlled experiment, or a natural environment (Ethology). In the present study we have bridged the gap without a true experimental manipulation, but in a controlled environment. In the neutral condition, subjects situated their Xs within the shapes in a non-random fashion. Subjects were also able to predict where others would place their Xs suggesting that this non-random behaviour is known and can be used by individuals. Lastly, even when asked to find a location least likely to be used by others, key areas within the shapes were left unused – suggesting that unconscious biases do exist, which theoretically could be used by an adversary to escape detection.

Future plans

Future research should be directed at detecting the limit of an individual's ability to use knowledge about other's behaviour in environments where no logical or deductive means of predicting behaviour could be used. An internet based experiment involving a Battleship-type game could accomplish this.

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Sommaire

Contexte

Il est généralement admis que l'être humain n'a pas tendance à adopter un comportement aléatoire, comme le démontrent d'ailleurs certaines études scientifiques. Il n'y a jamais eu d'effort concerté, en revanche, pour déterminer si l'être humain utilise cette information, ni même pour savoir s'il est conscient que les autres ont tendance à agir selon leur caractère. Si un individu est en mesure de constater des comportements non aléatoires à un certain niveau, puisqu'il sait faire les bons choix quand on lui demande de prévoir le comportement d'autres personnes, on peut dès lors extrapoler de nouvelles façons de concevoir l'intelligence humaine sur le plan des interactions avec autrui. Dans la présente étude, les sujets devront faire une marque dans une figure dessinée sur une feuille de papier (ou cliquer sur la figure apparaissant à l'écran dans la version Internet du test). Ils seront d'abord placés dans un contexte neutre (« mettez un X n'importe où dans la figure »), puis on leur demandera de mettre leur X là où ils pensent que d'autres personnes mettraient le leur. Enfin, on leur demandera de faire un X à l'endroit qui, d'après eux, ne serait vraisemblablement pas choisi par d'autres.

Résultats

En examinant la façon dont les X ont été placés dans les différentes figures présentées, on en vient à la conclusion que la nature du comportement non aléatoire n'a pas échappé aux sujets, car ces derniers ont réussi à repérer les endroits les plus fréquemment choisis, et ils ont su les éviter quand on le leur a demandé. Ils n'ont toutefois pas réussi à repérer les endroits qui avaient le moins de chances d'être retenus, c'est-à-dire là où peu de sujets ont mis un X, peu importe les circonstances au cours du test. Les applications de ces résultats font l'objet d'une discussion.

Signification

Les psychologues cherchent au fond à comprendre la pensée. Il leur faut toutefois extrapoler les données à partir de l'observation du comportement. Cela se fait généralement dans le cadre d'une expérience contrôlée ou en milieu naturel (éthologie). Dans la présente étude, cette lacune a été comblée sans qu'il y ait de véritable manipulation du point de vue expérimental, même si l'observation s'est déroulée en milieu contrôlé. Dans un contexte neutre, les sujets ont placé leurs X de façon non aléatoire. Ils ont également été en mesure de deviner l'endroit où les autres mettraient les leurs, ce qui indique que le comportement non aléatoire est un phénomène reconnu et qu'on peut tirer profit de cette information. Enfin, même lorsqu'on a demandé aux sujets de trouver l'endroit le moins susceptible d'être choisi, des surfaces importantes des figures proposées n'ont pas été noircies, ce qui laisse supposer certaines tendances inconscientes, qui en théorie pourraient être exploitées par un ennemi qui veut éviter d'être repéré.

Projets d'avenir

Les futurs travaux de recherche devraient viser à déterminer dans quelle mesure l'être humain est capable d'appliquer ce qu'il sait du comportement d'autrui aux situations dans lesquelles il ne dispose d'aucun moyen logique ni déductif pour prévoir ce que l'autre va faire. Dans cette optique, on pourrait réaliser une expérience basée sur Internet en faisant appel à un jeu du genre « bataille navale ».

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Introduction

Often times one is confronted with a question for which there is no logical answer. For example, in the game Battleship, "what is the first location to select for an attack?" While logic may constrain certain components of this selection, ultimately the actual location selected is not made by a logical choice. There are many possible responses, but instead of logic, they require either espionage, simple guessing, or memory. Espionage would involve secretly finding out where the other individual placed their ships and then selecting locations accordingly. With simple guessing one merely selects locations at random. Finally, a memory-based solution would use past play with the given opponent and knowing his/her favorite patterns. Using memory for what the opponent has done before is like being able to take into account a "factor" of the opponent to make the guesses more accurate. Suppose there were general human proclivities or tendencies that could be determined. Then, in the absence of espionage or memory of a particular opponent's past behavior, knowledge of such tendencies could be used to *guide* guessing. By taking the "human factor" in probability (Goodfellow, 1940) into account, performance could be improved beyond the level achieved by random guessing.

A Case Study In Non-Random Behavior

In 1937 a radio study of telepathy was conducted by the Zenith radio foundation. An experiment was performed during a radio broadcast where "telepathic senders" were employed to transmit a message out to the population. Members of the listening audience were encouraged to

mail in responses detailing the messages that they received. The results were astounding to the initial researchers. It appeared they had demonstrated mental telepathy! There was a very large number of respondents (well above chance) who reported all of the correct answers in the correct order on several days of the experiment.

Goodfellow (1938) repudiated this discovery by examining the data from the Zenith radio foundation and conducting some of his own experiments.

The original radio experiments were conducted in the following manner. A pair of symbols were first selected for the given day, for example, heads and tails. The audience was instructed that they would hear a bell indicating that the group of senders at the radio station is being presented one of the symbols selected at random. During the interval after the bell ringing audience members wrote down the first of these symbols that came to mind, in this case either a head or a tail. After a brief period of time another bell would ring ending that interval, and a spinning sound would occur followed by a bell indicating the presentation of a new symbol to the senders. Audience members mailed in their responses to the five consecutive presentations for that day. This was carried out on several separate occasions.

On examination of the method Goodfellow (1938) considered, and then demonstrated, that the instructions were biased some days. It seemed to him that on some days the instructions encouraged the audience members to select the same item as the first item in the sequence. By having independent raters assess the instructions Goodfellow found that this was indeed the case. On days when the bias

in the instructions matched the first item in the sequence respondents made a large number of correct responses to that first item. Moreover, on days when the bias did not match the first item respondents made a large number of incorrect responses to the first item.

But, this bias could not explain the entire pattern of results. That is because on days when the bias matched the first item there was a large percentage of respondents who got all five items correct. Conversely, if the first item did not match the bias in the instructions there was a large percentage who got every item wrong. Either of these events is very unlikely by chance.

Through some independent studies Goodfellow (1938) discovered something very interesting about human behaviour. Given random circumstances people do not behave randomly. Goodfellow performed several experiments, of which the following is an example. He asked participants in an experiment to select random sequences of 5 coin tosses. There were some very distinct patterns that emerged from the data and it turned out that people believe some patterns are representative of randomness while others are not. These representative patterns were the same as those selected by the Zenith radio foundation when there was subsequently a larger than average number of all incorrect, or all correct, responses. If one guessed correctly or incorrectly on the first item subsequent responses followed patterns that people typically select as random. On days when patterns that do not seem to people to be representative of randomness occurred (eg. head, tail, head, tail, head) the resulting performance tended to indicate that there was no effect of telepathy.

Goodfellow renounced the Zenith radio foundation findings of telepathy as a consequence of two artifacts of the experimental design. The first was that instructions were biased toward the first item presented, and the second was that the sequence of items presented was more frequently from the set of those selected by people as representative of randomness than would be the case if the sequences had truly been selected randomly.

There was much follow up of this particular line of investigation until the 60's (see Tune, 1964 for a review). Much of the work was focused on whether or not people tend to alternate and this work was principally used to aid in the design of perceptual experiments on liminal detection. More recently this line of research has gone largely unexplored. It has been applied to things like the design of true/false experiments and in the analysis of the perception of a "hot hand" in basketball (Gilovich, Vallone & Tversky, 1985). And, it has been instrumental in the argument over whether man understands statistical properties (Kahneman & Tversky, 1971; Kahneman & Tversky, 1996). But, the attempt to study human behaviour in settings that should produce randomness for its own sake has had little follow up. Furthermore, where it has been used the focus has been on whether an individual can produce random behaviour or not by taking large samples of sequences from that individual (Baddeley, Emslie, Kolodny & Duncan, 1998).

A fact that seems to have been missed is that even though the Zenith radio experiments did not demonstrate telepathy, they did demonstrate a reasonable facsimile. There was no mental transmission of information by the "senders"; but the way people behaved, and the results

of the experiment, demonstrate that individuals of a group (in this case the North American radio audience who responded and those in the Zenith Foundation who made the selections) have similar biases. The subsequent research into sequencing (Tune, 1964) allows anyone who knows that literature to pretend they are a telepath in that domain. They can compensate for the *human factor* in what should be random chance and predict behaviour well above chance.

Other Relevant Findings

While the above literature is interesting and related to the present work it deviates on one important component. In the sequence literature it has been demonstrated that individuals do not behave in a random fashion. However, the study that we are pursuing is more related to situations where the random pattern does not arise from the individual, but from a group (even though each individual contributes to the non randomness). Studies of these situations were often designed to determine individual preferences. We are most interested in preferences for kinds of things that do not, at face value, appear to have a strong cultural or social component.

Heywood (1972) asked individuals to select a number from 1 to 9. He found that when measured against chance the number 7 was the favorite. As can be seen in Figure 1, about 26% of participants selected that number first. Participants were then asked to pick a second number from 1 to 9. If both choices are taken into consideration the overall bias from all responses to select the number 7 is not quite as strong as illustrated; but the bias in the population, or the ability to guess whether

one of the numbers an individual selected is a 7, increases because to 40%. This property of design is important to remember because in the present study we are most interested in determining biases in the population.

Marshall (1994) also conducted a study into human preferences and it is his research that the experiments we will perform are modeled after. He examined whether individuals tended to have preferred locations. He presented participants with a blank piece of paper and asked them to place a dot on it. The result was not random placement of dots. Most of the dots were placed in the centre of the paper with a tendency toward the upper left quadrant and away from the lower quadrants. We have attempted to get examples of this data, copies of the original data, or a printed publication of the data. However, Marshall has not been helpful and has never published the above findings in print.

Another area in which preferences have been examined is the aesthetics of arbitrary shapes and lines. For many years the golden section has been believed to be very important in art and aesthetics. Fechner (1876/1925/1997) demonstrated that the golden section was important in rectangle selection (although he did diminish its importance by failing to find effects in other types of selection). More recently, Høge (1997) has shown a series of clear non replications of Fechner's findings. Both his results and those of other researchers such as Macrosson & Strachan (1997) have confirmed a more special place for centres, or halves, than golden sections. This confirms one of Marshall's (1994) experiments where he replicated his results by asking individuals to select the most aesthetically pleasing location. They again showed preference

for the centre, just as they had when asked to select a location without any guidance.

In all of the above examples the pattern of non random behaviour emerges from the populations. Asking any one individual to select a location or number could not reveal this non random pattern. However, with the knowledge of patterns derived from the population one can predict an individual's behaviour.

In basic psychology research preferences have been examined for things like coin tosses and sequences (Goodfellow, 1938; Baddeley et al, 1998) favorite numbers (Heywood, 1972), and favorite locations (Marshall, 1994), but there has been little more than speculation on why some preferences may exist. What seems firm is that people do not behave in a random fashion. What intrigues us, and has prompted the present study, is whether this preference information is well known either explicitly or implicitly (tacitly). Do people know the population preferences?

The Current Study

We propose that these preferences can be used to augment artificial intelligence (AI) systems such that they can be used more accurately to predict human behaviour just as the Zenith radio experiments generated an effect of artificial telepathy. This requires modifications to the previous research designs because merely knowing preferences is insufficient to predict behaviour in a meaningful and novel way. It is also insufficient to insure an advantage for the strategist who knows them for several reasons.

Perhaps preferences are inherently known in the population.

Psychology experiments have revealed that on a first coin toss people prefer heads to tails ($p=0.80$; Goodfellow, 1940). But, what is not known is whether people in general know this. How would an individual behave if they were told that someone else has selected heads or tails for a coin toss, and were then required to match the guesses of the other person? Chance would predict 0.50 probability of the person placing the coin and getting it correct. However, if one either implicitly or explicitly knows the natural tendencies of the population, or even believes that their own tendencies are common and can be extrapolated to others, then the probability of the person placing the coin matching the guesser will be greater than 0.50.

In the present study this is analogous to a new manipulation that will be made. We will be asking participants to make preference selections based on what they believe others would select. Individuals will be asked to select locations that others are most likely to select and locations that others are least likely to select as well as their own preferences.

In terms of strategy this information is critical. If one gathers the information about the human factor in probability it is more useful to the strategist to know whether people use this information naturally or not; otherwise, if people do use the information naturally, the strategist who knows it explicitly has little advantage. However, if the strategist has both pieces of information and knows not only that people have these tendencies, but that they know about them, then the strategist is always at an advantage whether the population tends to use knowledge of the

tendencies or preferences appropriately or not. This could get into a never ending regress of, "If you know that I know that you know that I know..." However, even if there is a regress of this sort there are likely much more strict limits placed on human memory in this situation than would be available to a strategist with a database of knowledge about behaviours. In that condition and artificial AI system, whether derived from a computer database of probabilities or rule based, could be a tremendous advantage to the strategist.

The knowledge of others is also important from the psychological perspective. To the Psychologist, failure of a population of people to produce random behaviour is not necessarily that interesting because it has been well established that people are rarely random. What may be important to the psychologist is whether the individual knows properties of that non random behaviour. If the individual understands the non random behaviour at some level, by making accurate choices when asked how other people would behave, then one would have evidence that the individual can plan and predict behaviours of another with minimal situational cues.

Furthermore, rather than merely speculate on the causes of the non random behaviour, we will attempt to relate that behaviour to demographic information. We will gather both cultural and general information that can be used to assess either extrinsic or intrinsic factors. The cultural information might be considered an extrinsic factor that could influence random behaviour. For example, Heywood's (1972) finding that the selection of the digit 7 is far above chance may be due to an extrinsic factor such as the belief in western culture that 7 is a lucky

number. Schizophrenia has been studied as an intrinsic factor and it has been demonstrated that schizophrenic individuals perform differently in selecting random sequences than normals do (Yakorzynski, 1941). Perhaps the heterogeneity this exemplifies extrapolates to the general population in terms of other non clinical intrinsic factors such as age, handedness, etc.

Although we are incorporating these factors into the research in the sense that we are surveying participants about them, we still have endeavored to design the project such that there is as little influence of these components as possible. People are simply asked to place a mark on a piece of paper or click in a box on a screen. The experiment is very generic and should be able to be applied to nearly anyone anywhere. In this way factors of intrinsic and extrinsic properties can be looked at as fairly as possible. We have no desire to prove any one factor is the cause of this non random behaviour and only wish to explore effects of potential factors. This is an exploratory project and the only explicit prediction we make is that we expect to replicate Marshall et al (1994) where are methods are similar to his.

We will be simply asking individuals to select locations in shapes. Shapes are used instead of blank pieces of paper (Marshall et al, 1994) to verify whether they can constrain or manipulate the random behaviour. It may be that the location is selected in terms of absolute coordinates within a given shape or perhaps it is relative coordinates within the shape.

Participants will also be asked to make the selection repeatedly. This is important for a number of reasons. Firstly, in Heywood (1972) it was found that making multiple selections increased the likelihood that

any one participant would select the item that was most selected over all. In terms of tactical information that is very important. Often the strategy being planned requires more than one behaviour within the given space and it matters more that one can see multiple selection preferences rather than just one. This is also a hedge against getting smaller numbers of participants for statistical tests. If we need to, we could collapse across the multiple selections and treat each one independently. While it is unlikely that the multiple selections are truly independent the way that independence will manifest itself is likely not a problem. We want to be able to statistically compare the distributions. Therefore, we will either need a very high N or we will need to geometrically bin the distributions into large sections that remove much of the variance. Collapsing across the first, second, and third favored choices may get this high N. We also would like to know more than one of the favoured locations within the space chosen and for this purpose it is of little importance which is selected first, only which is selected most often. Dependence across these selections likely does little more violence to our chi-squares analyses than the fact that locations selected will likely be somewhat dependent on the shape presented or the question asked. We still will treat these as independent across the dependent variable.

Participants will also be filling out a demographic questionnaire. It includes both intrinsic and extrinsic questions. While this questionnaire will be collected there is very little that we can do with it until we get a very high N or people's behaviour is not tightly clustered. This is because it is very unlikely, with the present procedure, that we will gather much variance in our cultural demographic questions. We expect a very high

proportion of participants to be native English speakers from North America.

The present study has been designed to generate a rich data set with many possible avenues for investigation. One of those that may be of some importance, but that is orthogonal to the primary question at hand, is the feasibility of doing research on the internet (the internet version of this experiment can be found at: <http://or.psychology.dal.ca/~xspot/>).. Appendix 3 covers this subject and will not be discussed further in the main body of the paper.

Method

Participants

There were 547 participants. 297 of these were college students from Dalhousie University. The remaining 250 were recruited from the internet through usenet postings and mailing lists at both Dalhousie University and DCIEM. The demographics of the participants are listed in Table 1.

Apparatus

There were two principal apparatus. For all of the participants run at Dalhousie University a paper and pencil questionnaire was used, an example of which is in Appendix 2. For all of the internet participants a Sparc 5 server was used to deliver, and randomize the stimuli. It was also used to store the results. For the web version a Java applet run on a computer used by the participant presented all of the shapes and collected the responses. After the shape presentation the final demographic questionnaire was a standard html form. There was a small percentage of the participants in the internet version of the experiment who failed to complete the demographic component of the questionnaire because they did not wait for the final demographic form to appear and left the web site.

The questions were of three principle types and can be seen in the sample questionnaire. They were: neutral (N), used to inquire about the participant's own most preferred locations; finding (F), in which the participant is asked to select a location most used by others; and hiding

(H), in which a participant selects the location other's are least likely to select.

There were also 4 shapes used that can be seen in the appendix as well. There was a square, and the same square rotated 45° into the shape of a diamond. Also, a circle with a quadrant cut out of it was used (at some angles this looks like a "pacman"). Quadrant 2 was cut out and the 180° rotation of this was also used (quadrant 4 removed). The reason we cut quadrant 2 is because we already knew that in Marshall et al (1994) participant's responses in a rectangular field tended toward the upper left so we felt it most appropriate to remove that section in order to observe how participant's responses are changed by the shape used.

The shapes were all of uniform size based on a 10 cm square. The circles fit in the square, the square was 10 cm, and the diamond was a rotated 10 cm square. For the internet, sizes were not uniform across participants in absolute measurement but depended on the size and resolution of the participant's monitor. They were still based on a square, but it was 167 pixels in size. In most standard computer configurations the shapes would be smaller than that used on paper.

Question orders were fully counter balanced across participants. Given that there were only 3 questions this led to 6 orders. Shape orders were not fully balanced because 4 shapes would lead to 24 shape orders that would need to be crossed with question. The resulting 144 conditions needed for such a fully balanced design would require an exorbitant number of participants for the counter balancing to be effective. Therefore, a selection of shape orders that represented each shape in the first position was chosen. With square being represented by

"S", diamond by "D", left cut circle by "L", and right cut circle by "R" the shape orders used were, *DLSR, LSRD, SLDR, RSLD*). For the paper and pencil version of the study, 24 different booklet templates were generated from the resulting 24 combinations. For the internet version, one of the 24 different orders was randomly selected.

Ethics

Ethical approval was granted by the human ethics review committee at Dalhousie University. It is a minimal risk experiment under the Tri-council guidelines for ethical approval of research with humans. All participants who signed up for the experiment were informed of the basic procedure before doing so. Before participating in the experiment all individuals read the informed consent form in Appendix 1.

Procedure

The essential procedure framework consisted of answering questions by making a mark in a shape followed by a multiple choice demographic questionnaire. Each subject made marks in each of the 4 shapes in response to each of the three types of questions:

- 1) Neutral : "Select any location you want in the shape below by marking a small x (about the size of this type) in the selected location."
- 2) Find : "Select the location in the shape below that you believe others are *most* likely to select by marking a small x (about the size of this type) in the selected location."
- 3) Hide : "Select the location in the shape below that you believe others are *least* likely to select by marking a small x (about the size of this type) in the selected location."

After the first response to a shape with a particular type of question, the participant was prompted for the two responses, as shown by the following example:

- 1) Second Question: "Select the location in the shape below that you believe others are next least likely select by drawing a number "2".
- 2) Third Question: Select the location in the shape below that you believe others are next least likely select by drawing a number "3".

The paper version of the question insured that people could not see immediately what the sequence of questions was by placing the first three on separate small sheets of paper instead of all on the first page as it appears in Appendix 2. On the internet each question was presented one at a time. After making a response on a given shape and type of question the prompt for the next response contained a mark in the previous location they selected similar to the way it would look on paper (x, 2, 3).

On the internet sometimes the server was slow at responding to the last shape selection and the demographic questionnaire was not filled out.

Method of Data Analysis

A Chi-Square test was used to test for differences among distributions of location selections. Because this test generally requires an expected frequency of 2 or greater per cell and a small number of cells the data were binned geometrically. For the diamond and the square there were 9 equal sized bins laid out as a 3x3 grid. For the circles with cutouts the area was divided into 9 equal size bins based on radial coordinates. The bins used can be seen in Figure 2. With this bin assignment the

chances of a dot being placed in any of the 9 bins that are contained in a given shape at random are equal.

Given the number of individuals whose participation we solicited, we decided to pool the three consecutive responses in order to increase the amount of data for each question and shape. One of the goals of asking the participant to repeat their response three times was to give each participant several opportunities to hit upon the most likely response (following the results of Heywood, 1972). Furthermore, this variable was included as a hedge against the difficulty associated with getting the large numbers of individuals to participate in a short period of time. The non pooled data is also provided for the purposes of data mining later.

All of the data can be seen graphed for each question and shape in Figure 3a and 3b. These are scatter plots with histograms of the density of values on the x placed above, and density of the y values placed to the right. The corresponding figures 4(a,b) and 5(a,b) contain these data separated by gender (male, female, respectively); figures 6(a,b) and 7(a,b) contain the data separated by self-reported handedness (right and left, respectively).

Sometimes it is difficult to tell what is going on in the scatter plot figures so another set of figures was produced in order to make it easier to see what is happening in the chi squares. Figures 8a through 12b are diagrams of the shapes carved into the bins used in the chi square with the proportion of responses entered in each bin. They are in the same order as the scatter plot graphs with Figures 8a and b for overall performance, Figures 9a and b are males, Figure 10a and b are females, figure 11 a and b are right handers' data, and figures 12 a and b are left handers.

Chi-square tests were the principle method of data analysis. For the test against random a Pearson chi-square test was used. These are presented in Table 2.

Looking at the graphs in Figures 3a and b it seems clear that the pattern of data is non random for all shapes in both the neutral and find questions. They also appear to be likely to be non random in the hide questions as well. Since there are 8 degrees of freedom in each test, the criterion chi-square for all tests is $\chi^2(8) = 15.51$, $p < 0.05$. With a minimum chi square of 233.6 for participants asked to hide a position in the diamond, the distributions all easily exceeded the criterion to be considered non random.

For all shapes and questions it appears that the most favoured location is the centre. This is true even for the hide question with all shapes except the square.

For squares there is a strong tendency to select positions toward the corners and centres of the edges with the corners being the stronger of the two. There is also a tendency to select items toward the top. This is true across all questions except hide where there the highest density of dots is in the bottom left corner and bottom corners are selected more than top.

With diamonds behaviour somewhat analogous to that in the square occurs. Participants select the centre most in all conditions and also select toward the corners of the diamond. However, selecting towards the centre of the edges is reserved for the hide question with this shape. It is interesting to note that in the hide condition a nearly blank ring exists around the most dense area in the centre of the square and the diamond.

Selections in the cut circular shapes are very similar to each other when described in terms of land marks. There is a strong tendency to select the centre in all conditions. There is also a tendency to select near the edges of the circle next to the cut in the neutral and find conditions. These positions are the only corners on the shape. There is also a relatively high density of selections on a line at a 45° angle opposite the cut section. This would be approximately the centre of gravity of the figure.

We are calling the centre of the cut circles the centre of the virtual circle which would exist without the cut. The reasons for this are because it is convenient, and matches well with the data for the squares and diamond. It is recognized that the true centre is closer to the centre of gravity of the cut circle and somewhere in the quadrant opposite to the removed quadrant. However, it appears as if our participants treated the circle in which our figures could be inscribed as the basis for determining the center, if the data can be generalized from the diamond and the square.

Chi-square tests were also used to make comparisons among the various groups as well. There were tests for the effects of gender, handedness, and type of question. As can be seen from Table 2 there were significant chi-squares for several conditions across gender. It appears that, in general, females had tighter distributions around the most commonly selected locations in the find condition. In addition, in the neutral squares conditions females had a more diffuse distribution of responses than males. There was only one significant chi-square for handedness that occurred when the subject was asked a neutral question

about a diamond. From the scatter plot graphs is difficult to tell exactly what the reason for this is. However, when looking at the binned data it appears that with the neutral diamond left handers favoured the left side and right handers favoured the right side. However, both groups essentially picked the same favoured locations.

One should also note that the magnitude of the chi-square is indicative of the degree to which two groups differ if the N, and cell numbers are equivalent. This is true for the present data within any group of tests defined by the question (e.g. there are 12 comparisons in the group of tests for randomness or for gender). but not between groups except for the comparisons between types of questions.

The magnitude of the chi-squares when comparing across questions reflected an expected pattern. The chi-square for the comparison of hide and find questions was greatest while the comparison between neutral and find questions was lowest. However, all were very high.

The fact that there is a statistically significant difference between the neutral and find questions is a potential point of confusion. It can be seen from an examination of the figures that participants could successfully select the most likely chosen locations. The modes of these distributions are nearly identical in all cases. The distributions differ more in the degree to which they cluster than anything else. The fact that these distributions differ statistically is thus less meaningful in this context.

It is exciting to find that the hide and find distributions differ so much. However, it appears from first glance that, unlike predictions, the hide is not just a mirror image of the find. On the contrary, in several

conditions the hide appears to have the same mode as the find and only looks somewhat more random (as indicated by the much lower chi-squares against random values in those conditions). However, keep in mind that the heights of the histograms are not comparable across plots and that even though the modes are similar, the magnitude of the modes is drastically different. In addition, areas adjacent to the modes in the hide condition have very few selections. The true picture can best be understood by looking at both the scatter plots, and the plots of proportions of responses binned into the sections used for the chi-square (see Figures 8a and 8b for the overall proportions. In the proportions it can be easily seen that people are good hidiers. In every condition, the bin that contains the highest proportion for both neutral and find questions also contains the lowest, or nearly the lowest, proportion for hide questions. It should be noted that the hide was not entirely successful because, especially in the circular shapes, there was a strong tendency to make selections in some of the more popular sections. This is especially true in the circular shapes near the corners.

Finally, a warning about the probability tests with these chi-squares is warranted. One may be tempted to perform Bonferroni corrections on these data, but that depends on how you wish to interpret them. If one wants to take any of the tests in a group and use it to say that the groups differ then a Bonferroni correction should definitely be performed. For the groups of size 12 the new critical chi-square would be 22.38, $p < 0.0043$, and the new critical chi-square for groups of size 4 would be 20.09, $p < 0.01$. However, if the question being asked is about the specific test in the group then we suggest that the correction not be

performed. Testing any one hypothesis should in itself be independent, arguing that a Bonferroni correction be done in this instance is just short of suggesting that one should figure out how many hypothesis tests one plans to do in one's lifetime and correct for that. Given that we are generally using the chi-squares for specific comparisons we did not perform Bonferroni corrections

Discussion

We have replicated the common finding that people do not behave randomly, and we have extended this observation to the spatial arena (Marshall, 1994). Given a variety of shapes, orientations, and question orders people tend to prefer the centre of an object and other regions (such as the corners of a square) which can be seen in the figures.. Furthermore, we have demonstrated that if asked how others would behave, individuals demonstrate knowledge of that non random behaviour. When asked to make selections that others would be unlikely to make, as a group they seem to fail at this in the fine grained analysis, but the course grained analysis seems to reveal a degree of success.

Why is there such a difference in the appearance of the fine grained and coarse grained analyses with respect to the hide question? The following scenario may explain things. Suppose that about 90% of participants select one of the more common locations when answering a find question while 10% select the uncommon locations. Then further suppose that, when hiding, those who did not choose one of the most common locations select the most common locations under the belief that it is very unlikely someone would hide there; perhaps they just seem to obvious to this small sub population. When they do that they most often select the centre, and do so more accurately than those who select that location as a matter of course (they are attempting to hit the *most* obvious spot). This would generate relatively dense populations of responses on the centre and to some degree other commonly selected areas. Now further suppose that the 90% of the population who understand where the

most dense areas are avoid the centre area. The reason centre may be the mode is because those who are hiding in other locations have a vast expanse of locations to select from and none may accrue to as high a level as the exact centre while those who select the centre do so with high precision. The result would be that the area around the centre would be nearly vacant (and this was what was found). This pattern was also found for other densely selected areas such as the upper corner in the diamond.

At a coarse level of analysis people are generally effective hidiers and finders in this unconstrained situation.

Discovering that people are effective finders may have many applications. For example, researchers into preferences for commercial products might save time and money by enlisting fewer participants and asking different questions. Rather than ask individuals what they prefer, ask what they believe others will prefer. The resulting more tightly distributed clusters of responses will allow the pattern of preference to emerge with a smaller sample size.

Psychologists can study this information in and of itself. One might attempt to ask whether the knowledge was explicit or implicit (Berry, 1993; Dienes & Perner, 1999). While this was not tested in the present study, informal inquiries made into participant's confidence after they completed the study revealed that for the find questions they were highly confident of their responses, however for the hide questions they exhibited very low confidence that they were successful. They believed that they explicitly knew the correct answers to the find questions but not the hide. This may lead one to speculate that the successful hiding behaviour was based on implicit knowledge but that finding was based on

explicit knowledge. What that knowledge is based on, is unclear. Perhaps for the find it was as simple as knowing their own preferences and extrapolating that out of the population (Gilovich, Jennings & Jennings, 1983) (see data mining section for a description of how to assess this). Certainly the gender differences seem to indicate that might be true. Not only did females tend to distribute responses more toward the corners in the left cut circle, but they also did so in the find condition suggesting that they were either basing their responses on their own performance or only were able to base it on how they guessed other females would perform.

Another question of interest is how people acquire this knowledge. How do they know the most commonly selected locations? Is it an innate property or is it something that is acquired? These are questions that we cannot answer with our present set of data. There was only a handful of responses from individuals without a North American or Western European background so the assessment of performance from other cultures is difficult. It may be possible to generate more data from other cultures if the web site could be designed in other languages.

We can tentatively conclude that there seem to be some innate factors that influence the selection of locations. While handedness did not have much affect at all gender seemed to have a significant effect. Women tended to be better finders than men because the clusters of their responses to the find question more tightly grouped even though their performance in the neutral situation appears less clustered.

This type of AI research might be considered as bridging the gap between expert systems, and neural nets. Ideally a neural net would have

to be trained from infancy with all the experiences of a human being. Similarly, this AI will use the sampled behaviour of human beings to extrapolate that first step. Moreover expert systems should not depend on the filtered knowledge of experts, but the knowledge base they use. It may be possible to derive this knowledge base from sampling the population in an efficient manner. No expert is needed, and no training is necessary for a neural network.

One might wish to make a database of the collected information and use it in a tactical situation. One could at least develop a system from the present data that would be as capable as any individual. And, given that this is a preliminary study that is a promising finding.

Future research should be directed at detecting the limit of an individual's ability to use knowledge about other's behaviour in environment's where no logical or deductive means of predicting behaviour could be used. In order to do that the questions must be more challenging and the location selection must be more complex. A game like Battleship might accomplish both of those. The question becomes more complex because the person is trying to hide ships under the knowledge that the other person knows they are trying to hide ships and a potential infinite regress is set up. In this case knowledge of others may be impossible for an individual to utilize efficiently. Furthermore, the placement of 5 items of varying sizes is more difficult than 3 tiny marks if one is trying to select the least likely to be targeted locations.

Also, one of the great bonuses of using a game is that getting data would be very easy. An internet based experiment could gather many times more data than the present one. It has been demonstrated that

games are an excellent way to motivate participants to develop lots of data (Case, Ploog & Fanting, 1990).

Another advantage the game provides is that one can assess differences in performance whether the participant believes that they are playing a computer opponent, or a live opponent. A scenario could be set up where individuals play each other or computer opponents. Whether they are informed of this is counter balanced so that half are deceived and half are not. Perhaps if the individual believes that they are playing a computer opponent they will behave differently than if they believe it another human being (stress might be made to emphasize that the opponent is either a poor or good player as well).

More generally, AI derived from databases of this kind of information can be used to predict human behaviour. While the database for a game of Battleship may be quite specialized we believe that general principles may emerge that could be applied to other scenarios as well. Additionally, while the game superficially reduces the seriousness of the endeavor it greatly eases, and reduces the cost of, data collection.

Psychologists seek ultimately to understand the mind. But, this must be extrapolated from the observation of behaviour. Typically, that is either in a controlled experiment, or a natural environment (Ethology). In the present study we have bridged the gap without a true experimental manipulation, but in a controlled environment. If information found this way can be used to derive models that can predict human behaviour then perhaps new theories of the mind can be developed.

Future Data Mining Potential

1. Get the Euclidean distances between neutral and find answers for each individual. Then get mean Euclidean distances for neutral and find answers selected at random (i.e. different people's answers). If the mean Euclidean distances differ little (the means should still be the same), or are lower in the randomized group then people successfully based their responses on what they believed others would do. However, if the mean Euclidean distance is less for a person's own responses than others, then perhaps their behaviour is based only on extrapolating how they behaved themselves to the population and is a false consensus effect.
2. Permute 1 through all of the questions.
3. Use correlations to examine whether the good hidiers are also good finders.
4. Look at the individual question orders to see if hiding and finding are consistent across the three individual selections.

(John Christie would be available to consult on any of these future data mining adventures)

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Table 1. Demographic frequencies and proportions for all participants in the experiment.

Gender	freq.	prop.
Male	201	0.40
Female	304	0.60
Handedness		
Right	444	0.88
Left	58	0.12
Age		
<12	3	0.01
12-18	68	0.14
19-25	229	0.46
26-35	86	0.17
36-45	66	0.13
46-55	36	0.07
56-65	7	0.01
66-75	3	0.01
>75	0	0.00
Education		
grade or less	23	0.05
some high school	22	0.04
high school	34	0.07
business/trade	11	0.02
some college/univ	239	0.47
associate degree	5	0.01
bachelors	58	0.11
some grad. or prof	36	0.07
graduate or prof	77	0.15
First Language		
English	239	0.47
Not English	266	0.53
Blank	42	0.08
Ethnic Background		
European	437	0.89
Asian	26	0.05
African	6	0.01
American Aboriginal	9	0.02
Other	13	0.03

Table 2. These are the chi-square comparisons for data categorized in the same way as the included figures. In the column labels N, F and H stand for the neutral, finding and hiding questions respectively. The S, D, L, and R stand for the square, diamond, left cut circle, and right cut circle respectively.

	NS	ND	NL	NR	FS	FD	FL	FR	HS	HD	HL	HR
Test against random												
χ^2	781.8	905.3	548.0	556.2	1420.1	1683.7	1090.6	1089.5	470.6	253.6	299.5	349.8
ν	1620	1628	1627	1629	1627	1630	1632	1634	1633	1627	1634	1626
Comparison tests												
male v female												
χ^2	64	90	251	113	172	155	299	338	59	82	54	83
left v right												
χ^2	89	180	29	65	63	32	60	82	57	55	62	99
Find v Hide												
χ^2	5400	9058	4403	4345								
Neutral v Find												
χ^2	807	1068	621	595								
Neutral v Hide												
χ^2	3058	4856	2364	2607								



Figure 1. The relative frequency of responses when individuals are asked to "pick a number" between 1 and 9. Chance is indicated by the horizontal line. (From Heywood, 1972, Table 1)

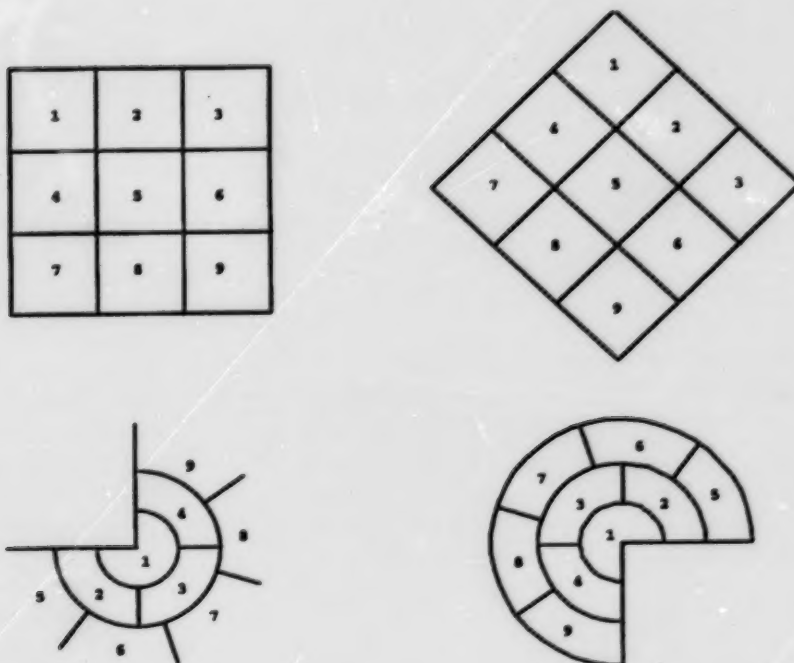


Figure 2: Bins that the data were put in for each shape.

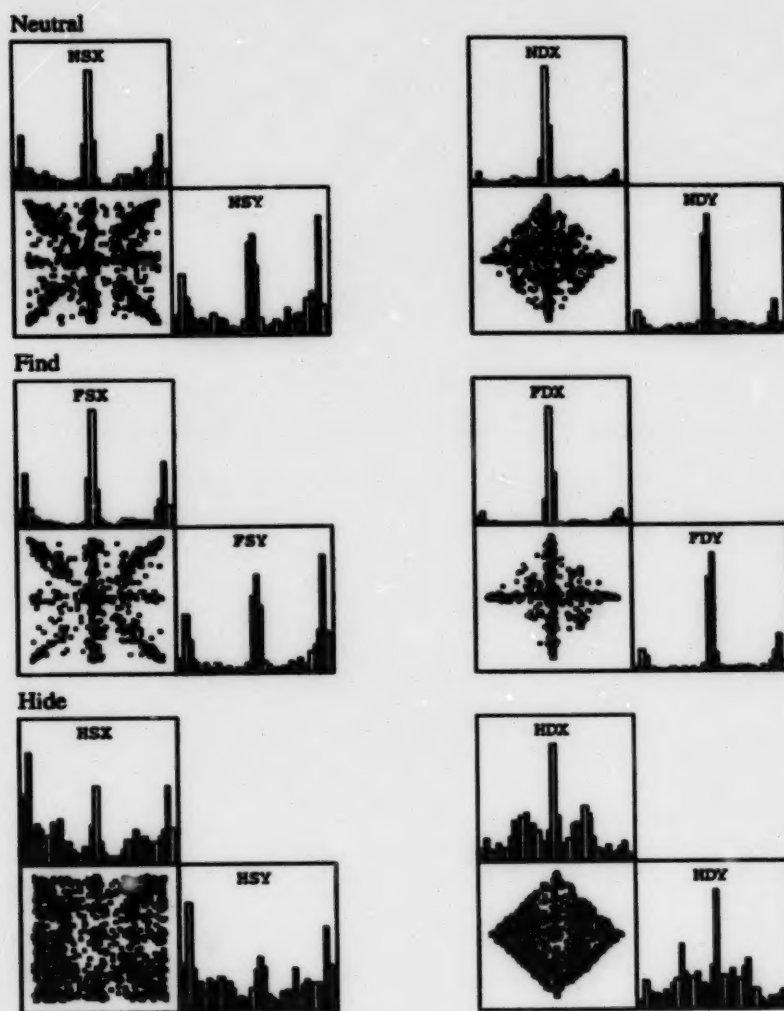


Figure 3a: Scatter plots for all the participants across all questions for the diamond and square shapes; N = 547

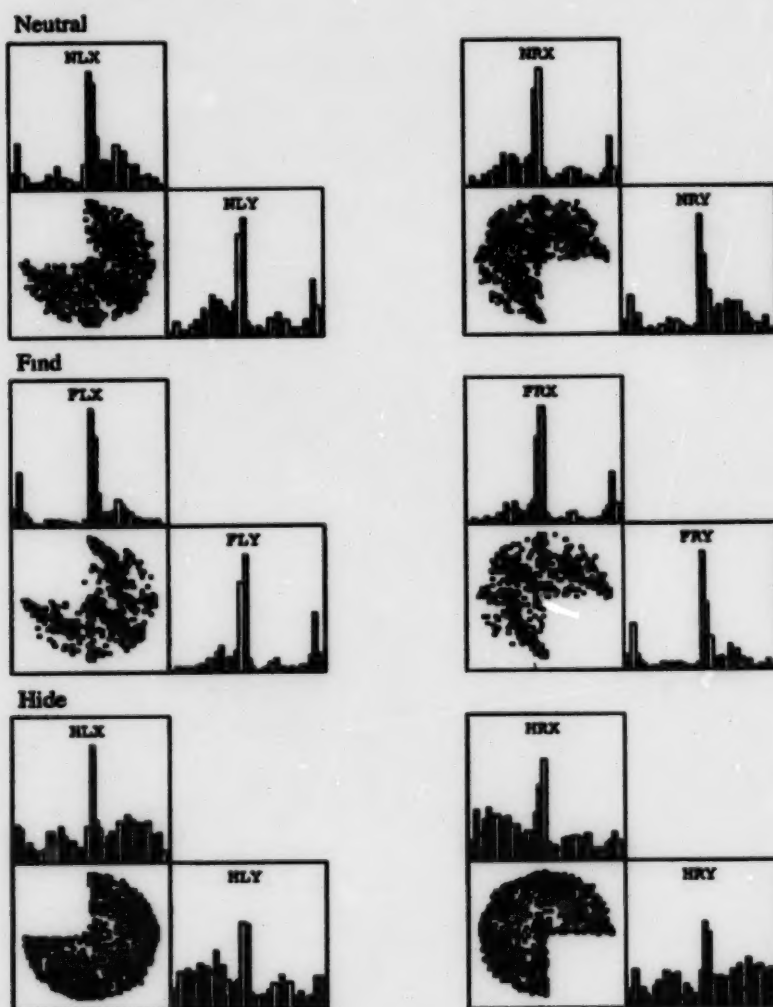


Figure 3b: Scatter plots for all of the participants across all questions for the circular shapes; N = 547

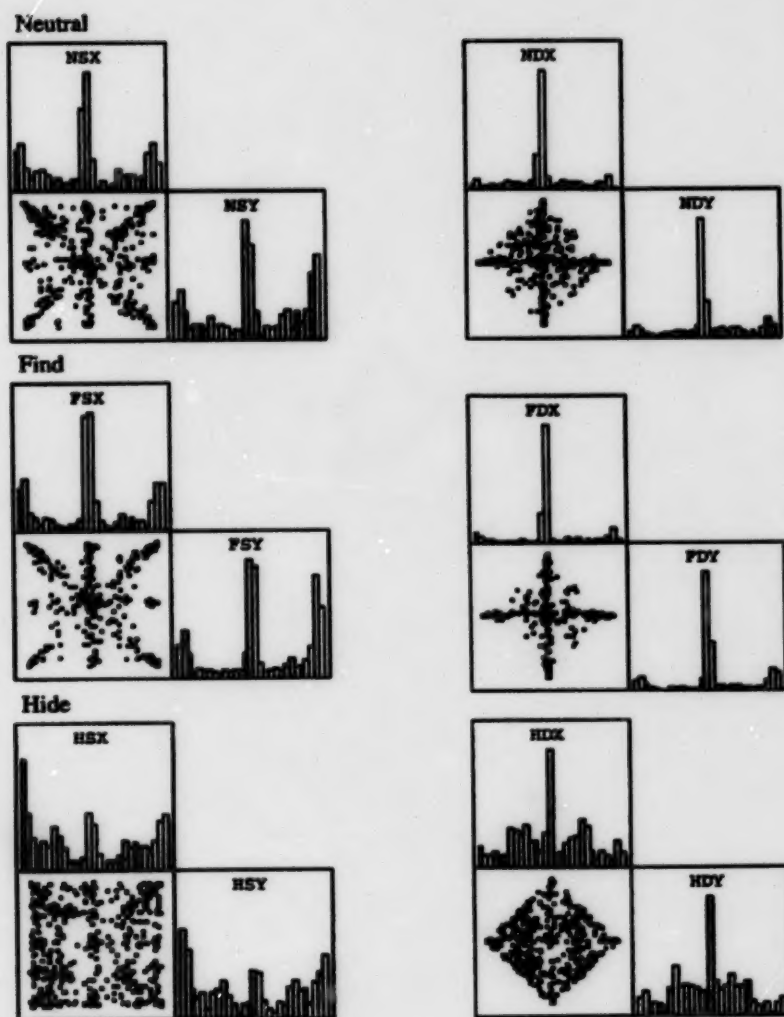


Figure 4a: Scatter plots for male participants across all questions for the diamond and square shapes; N = 201

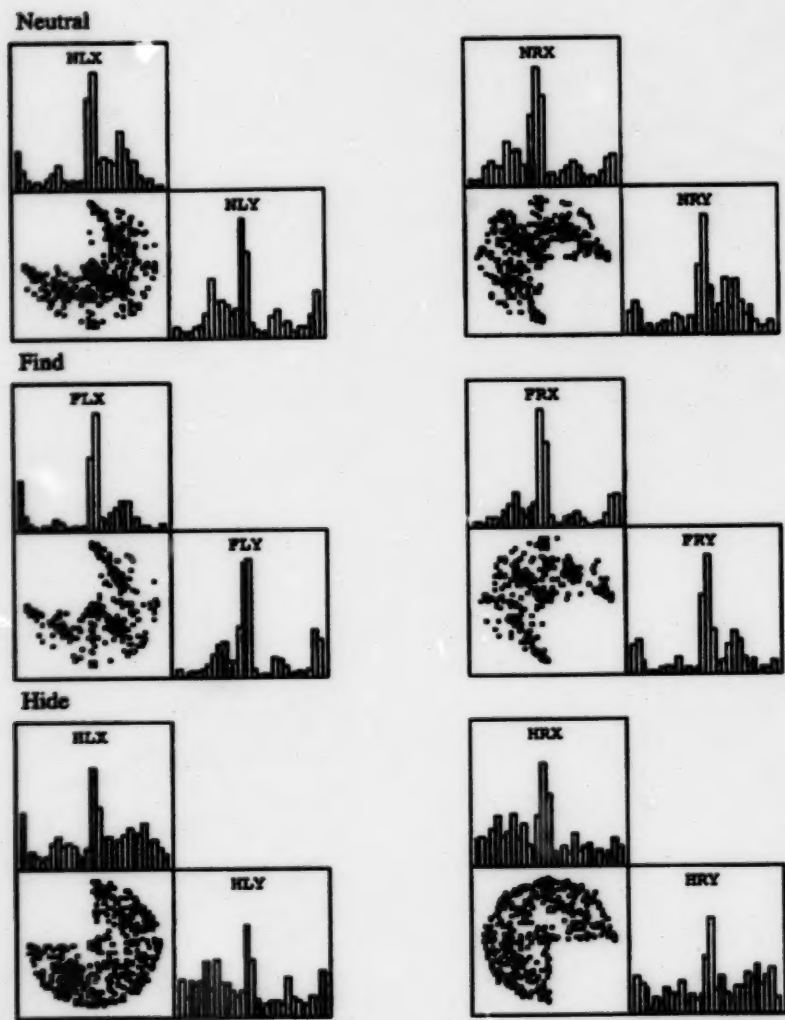


Figure 4b: Scatter plots for male participants across all questions for the circular shapes; N = 201

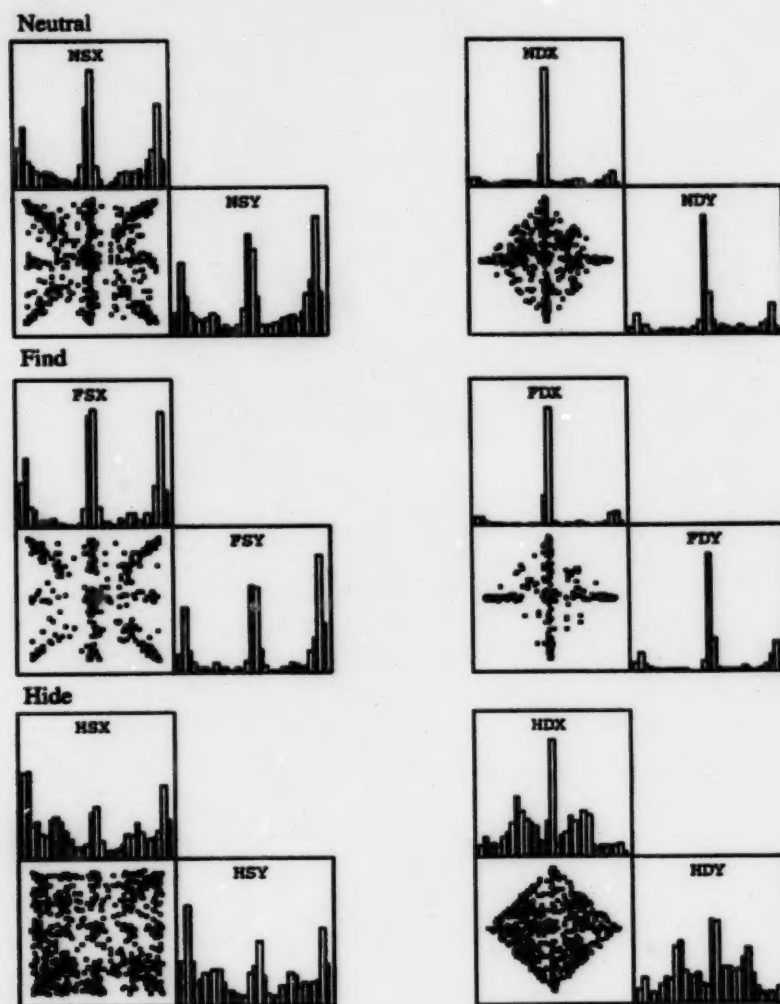
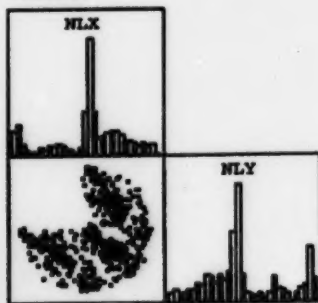


Figure 5a: Scatter plots for female participants across all questions for the diamond and square shapes; = 304

Neutral



Find



Hide

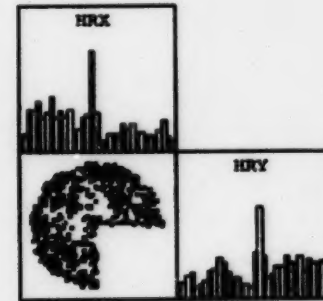
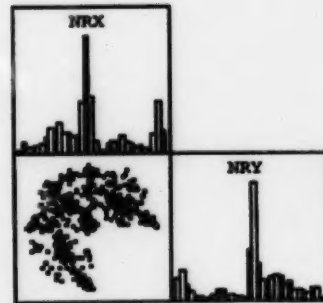


Figure 5b: Scatter plots for female participants across all questions for the circular shapes; N = 304

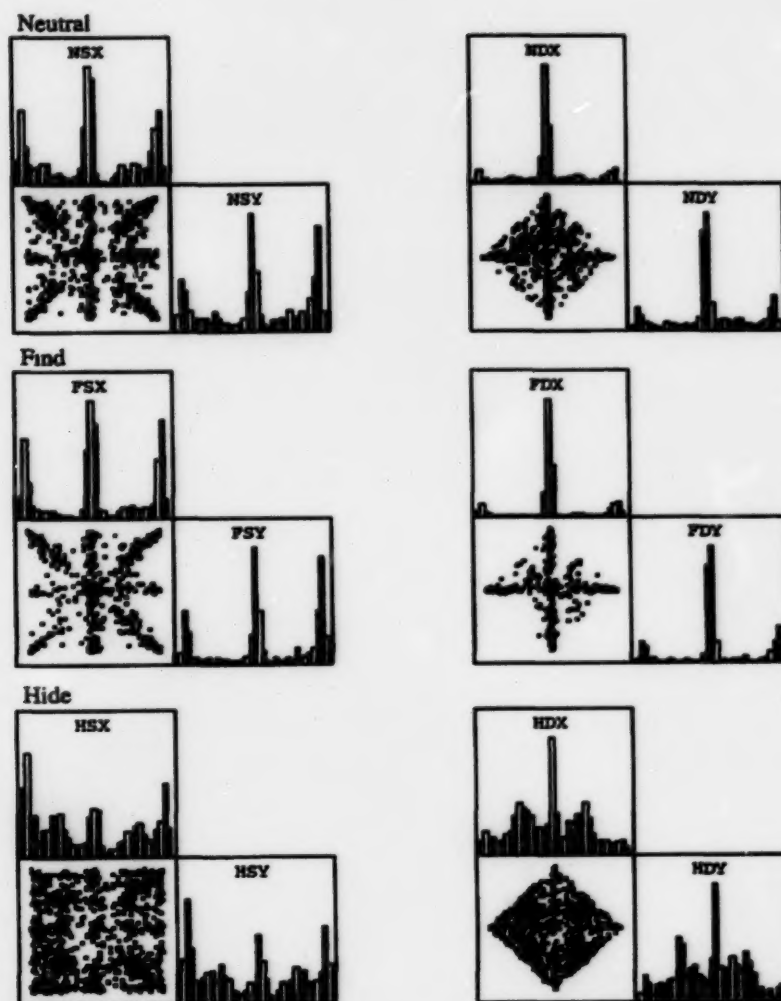


Figure 6a: Scatter plots for right handed participants across all questions for the diamond and square shapes; N = 446

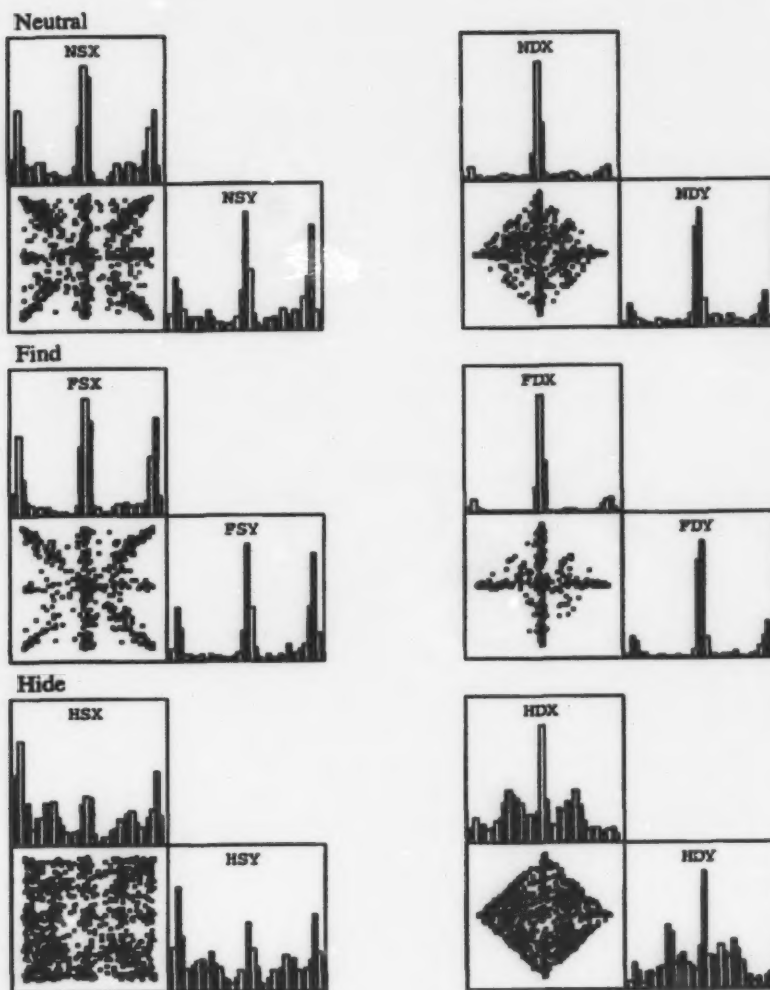


Figure 6b: Scatter plots for right handed participants across all questions for the circular shapes; N = 446

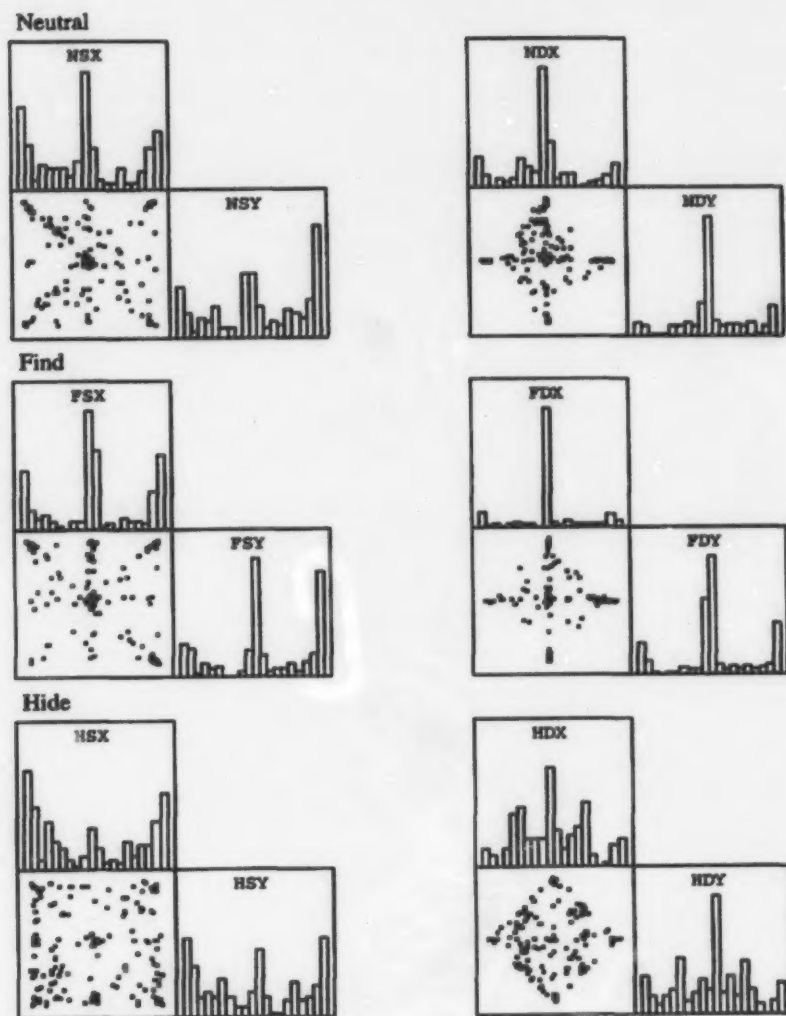


Figure 7a: Scatter plots for left handed participants across all questions for the diamond and square shapes; N = 58

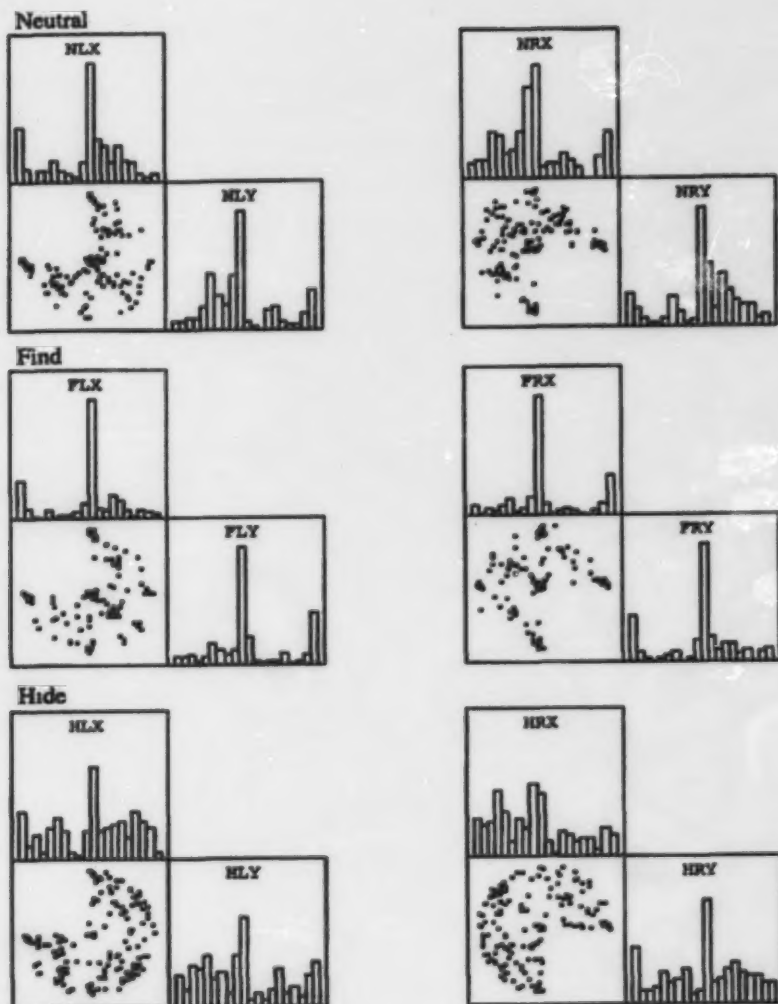


Figure 7b: Scatter plots for left handed participants across all questions for the circular shapes; N = 58

Neutral

.16	.07	.16
.04	.25	.06
.09	.06	.11

Find

.16	.06	.18
.02	.32	.04
.06	.04	.13

Hide

.17	.06	.12
.10	.06	.07
.19	.08	.14

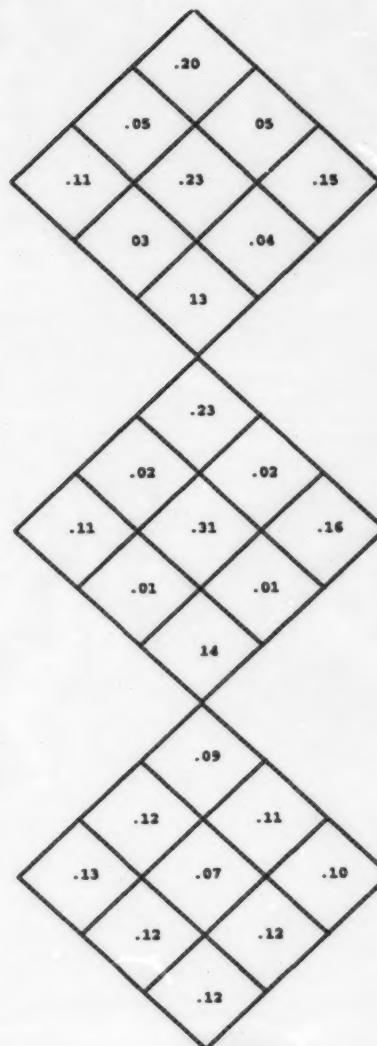


Figure 8a: Proportions of dot placements in each bin used for the chi-square analyses for all participants across all questions for the diamond and square shapes; N = 201

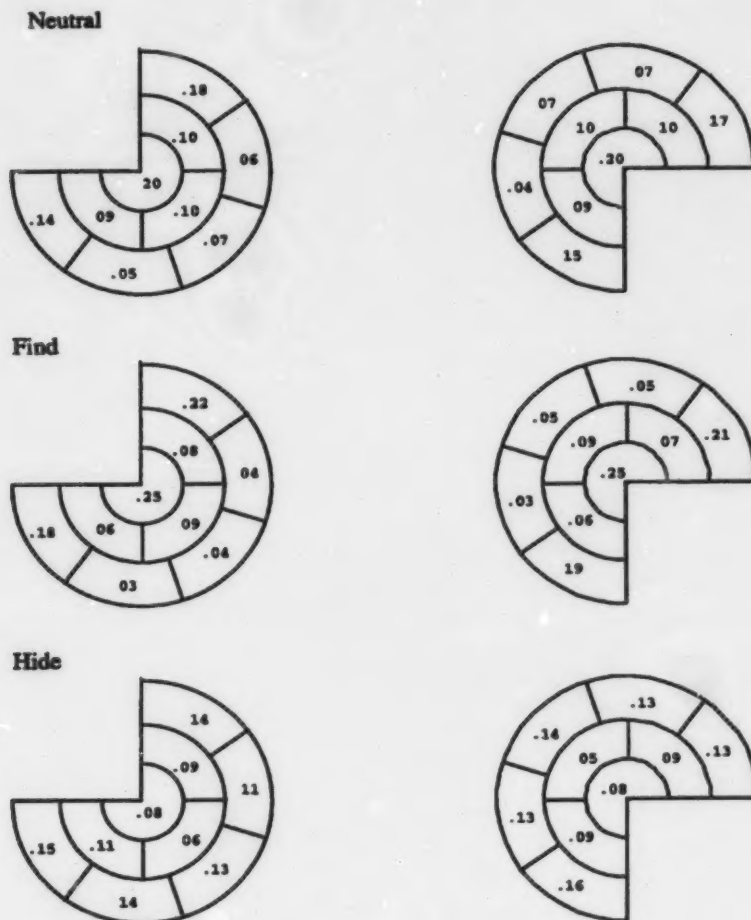
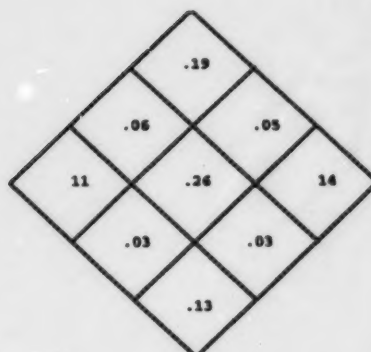


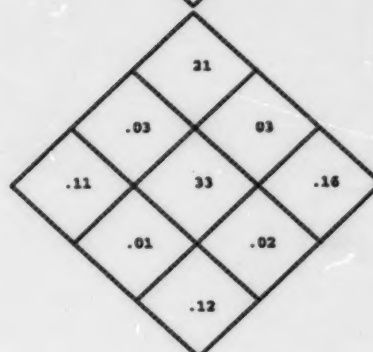
Figure 8b: Proportions of dot placements in each bin used for the chi-square analyses for all participants across all questions for the circular shapes; N = 201

Neutral

17	.07	.15
.03	.27	.06
10	.06	.10

**Find**

.16	06	.16
.03	35	.04
.07	.05	.09

**Hide**

.17	.07	.13
.09	.07	.06
.20	.07	.15

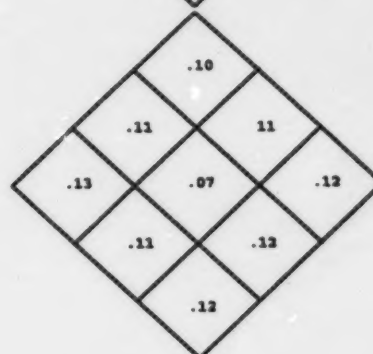
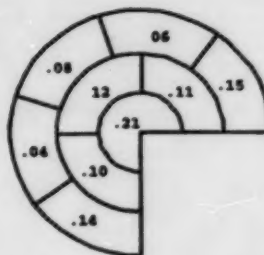
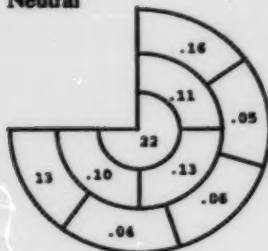
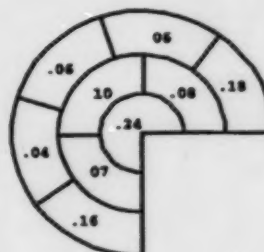
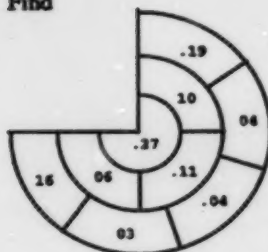


Figure 9a: Proportions of dot placements in each bin used for the chi-square analyses for male participants across all questions for the diamond and square shapes; N = 201

Neutral



Find



Hide

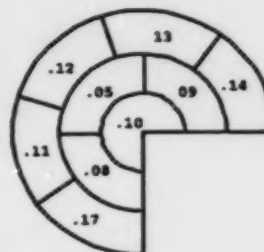
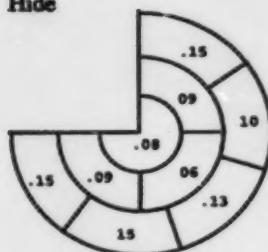
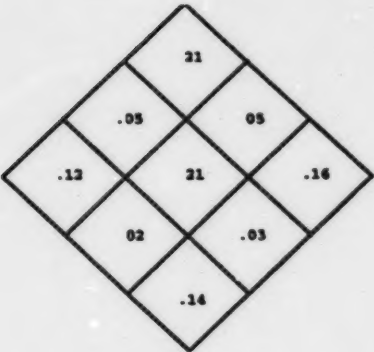


Figure 9b: Proportions of dot placements in each bin used for the chi-square analyses for male participants across all questions for the circular shapes; N = 201

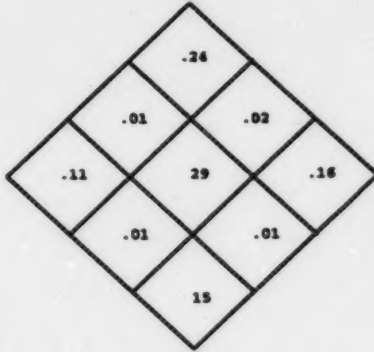
Neutral

.17	.07	.17
.04	.23	.06
.09	.06	.12



Find

.17	.05	.19
.02	.30	.03
.06	.04	.14



Hide

.16	.05	.12
.11	.06	.08
.20	.09	.13

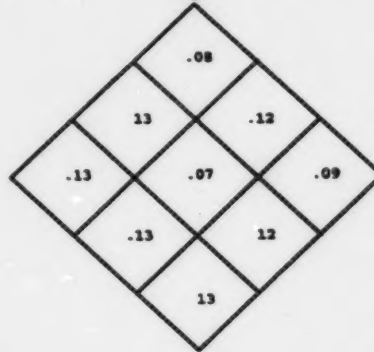


Figure 10a: Proportions of dot placements in each bin used for the chi-square analyses for female participants across all questions for the diamond and square shapes; N = 304

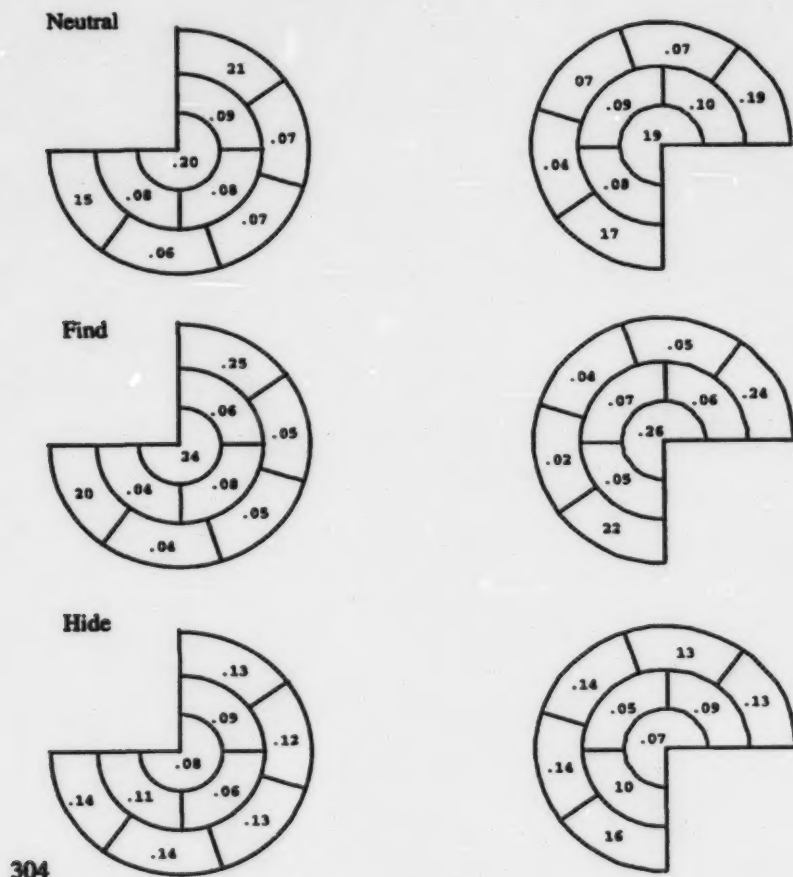


Figure 10b: Proportions of dot placements in each bin used for the chi-square analyses for female participants across all questions for the circular shapes; N = 304

Neutral

.16	.07	.16
.04	.25	.06
.09	.06	.12

Find

.17	.05	.18
.02	.32	.04
.06	.04	.12

Hide

.16	.06	.12
.10	.06	.07
.20	.09	.13

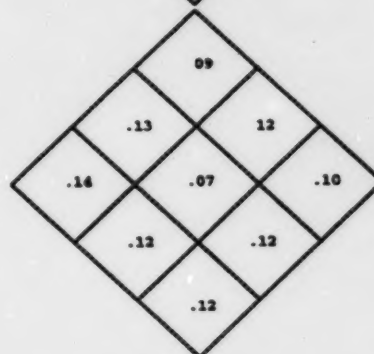
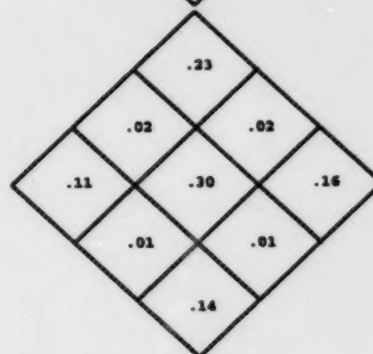
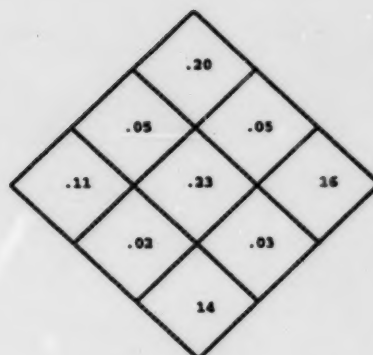


Figure 11a: Proportions of dot placements in each bin used for the chi-square analyses for right handed participants across all questions for the diamond and square shapes; N = 446

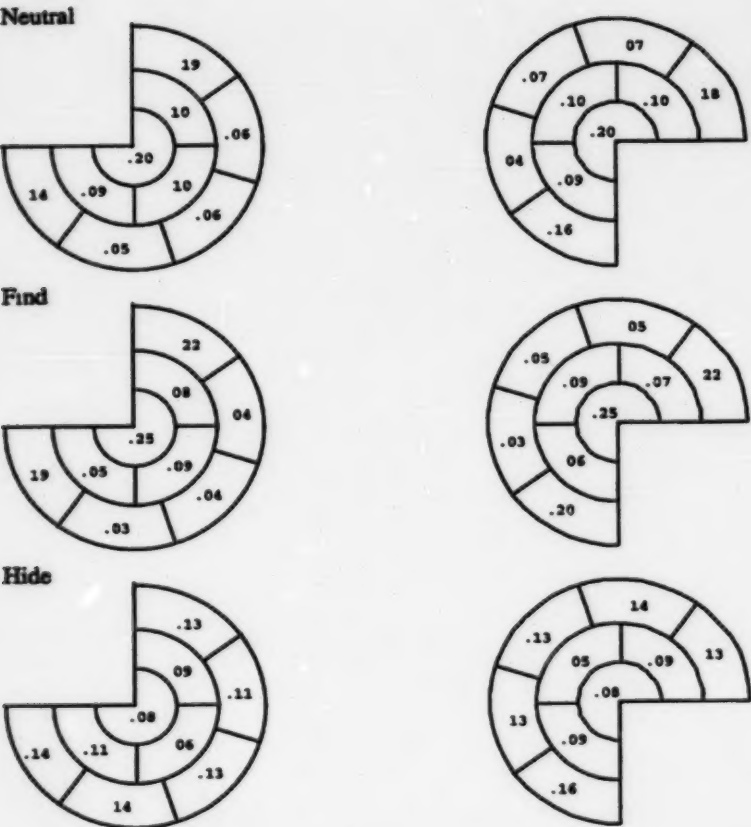


Figure 11b: Proportions of dot placements in each bin used for the chi-square analyses for right handed participants across all questions for the circular shapes; N = 446

Neutral

22	.07	.11
03	.24	.06
.12	.05	.09

Find

.16	.08	16
.03	.33	03
.04	05	13

Hide

.18	03	.14
.09	.07	.07
.20	.07	.15

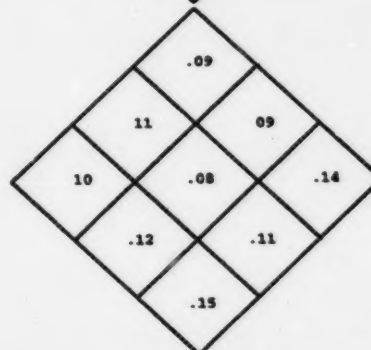
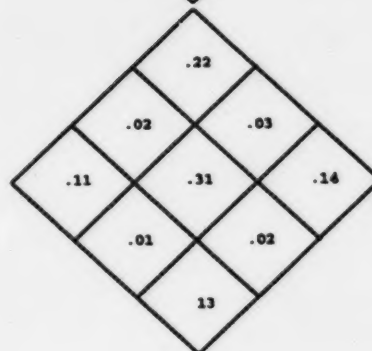
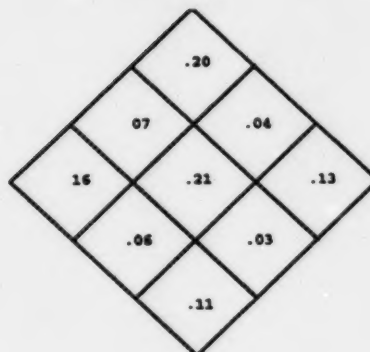


Figure 12a: Proportions of dot placements in each bin used for the chi-square analyses for left handed participants across all questions for the diamond and square shapes; N = 58

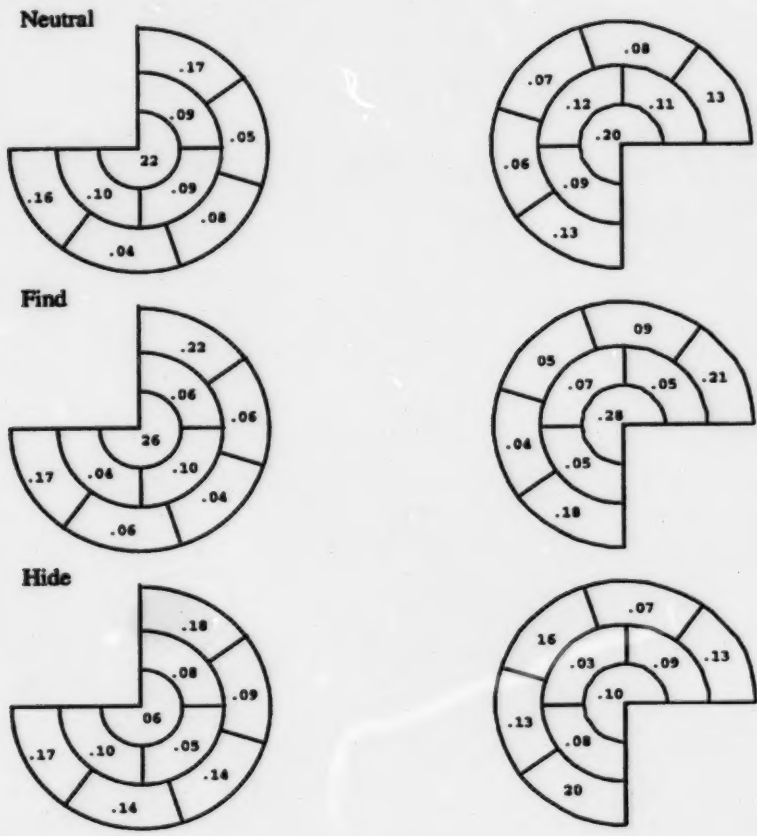


Figure 12b: Proportions of dot placements in each bin used for the chi-square analyses for left handed participants across all questions for the circular shapes; N = 58

Appendix 1 (Informed consent form)

INFORMED CONSENT FORM

TITLE OF RESEARCH PROJECT: Preferences in Human Spatial Behaviour

STAFF MEMBER RESPONSIBLE:

Dr. R. M. Klein
Psychology Department, Dalhousie University
494-6551

TO ALL PARTICIPANTS:

Purpose of the research project:

To explore spatial preferences.

Task requirements:

You will be required to select locations in two dimensional space. Afterward there will be a short questionnaire in which you will be asked to provide information which describes, but does not identify you.

Your participation in this experiment is entirely voluntary. Should you wish to discontinue your involvement in this study you may do so at any time without penalty and without loss of expected compensation.

All information given to us will be treated as strictly confidential.

Risks and benefits associated with participation:

There are no negative consequences associated with participation in this experiment. You will benefit through the opportunity to learn how a Psychology experiment is conducted. Questions or comments are welcomed at the end of the session.

Please confirm that you understand the information provided above, and that you are aware that all records are entirely confidential, and that you may discontinue participation at any point in the study. Feel free to address any question you may wish to the experimenter, either now or after you have participated. Individuals with specific ethical concerns should contact either Dr. R. M. Klein (494-6551) or a member of the Psychology Ethics Committee.

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Appendix 2

The Example Questionnaire

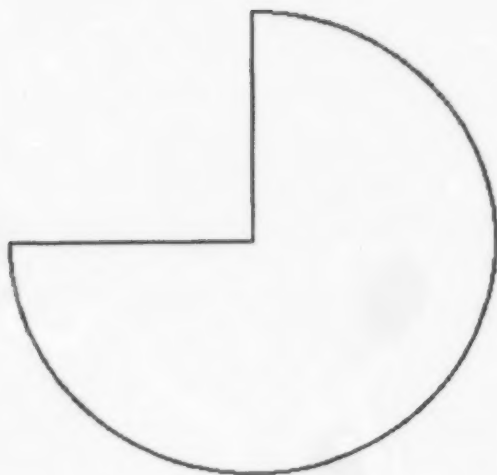
Select any location you want in the shape below by marking a small x (about the size of this type) in the selected location.

Select another location in the shape below by drawing a number "2".

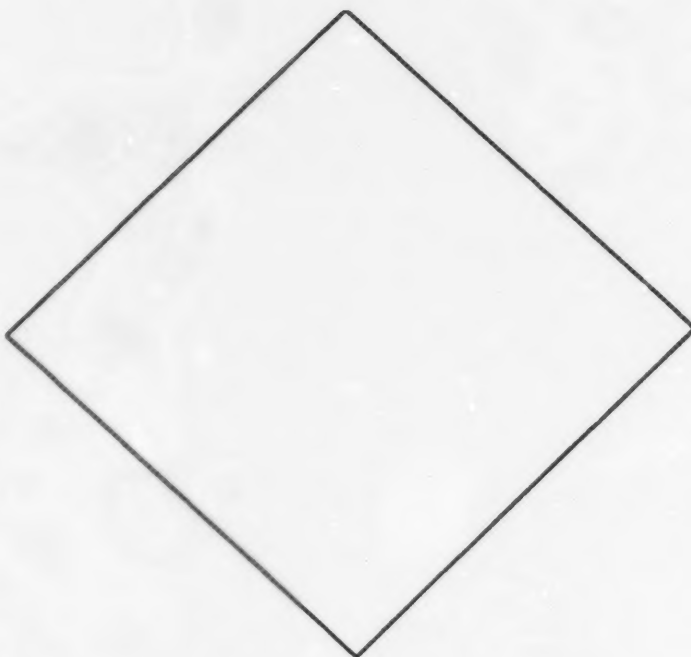
Select a third location in the shape below by drawing a number "3".



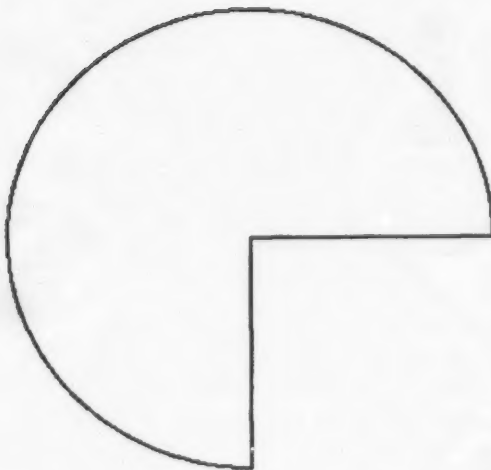
Select any location you want in the shape below by marking a small x
(about the size of this type) in the selected location.
Select another location in the shape below by drawing a number "2".
Select a third location in the shape below by drawing a number "3".



Select any location you want in the shape below by marking a small x
(about the size of this type) in the selected location.
Select another location in the shape below by drawing a number "2".
Select a third location in the shape below by drawing a number "3".



Select any location you want in the shape below by marking a small x
(about the size of this type) in the selected location.
Select another location in the shape below by drawing a number "2".
Select a third location in the shape below by drawing a number "3".



Select the location in the shape below that you believe others are *most* likely to select by marking a small x (about the size of this type) in the selected location.

Select the location in the shape below that you believe others are next most likely select by drawing a number "2".

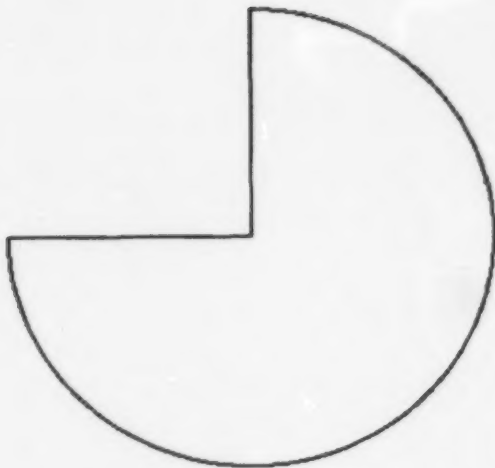
Select the location in the shape below that you believe others are next most likely select by drawing a number "3".



Select the location in the shape below that you believe others are *most* likely to select by marking a small x (about the size of this type) in the selected location.

Select the location in the shape below that you believe others are next most likely select by drawing a number "2".

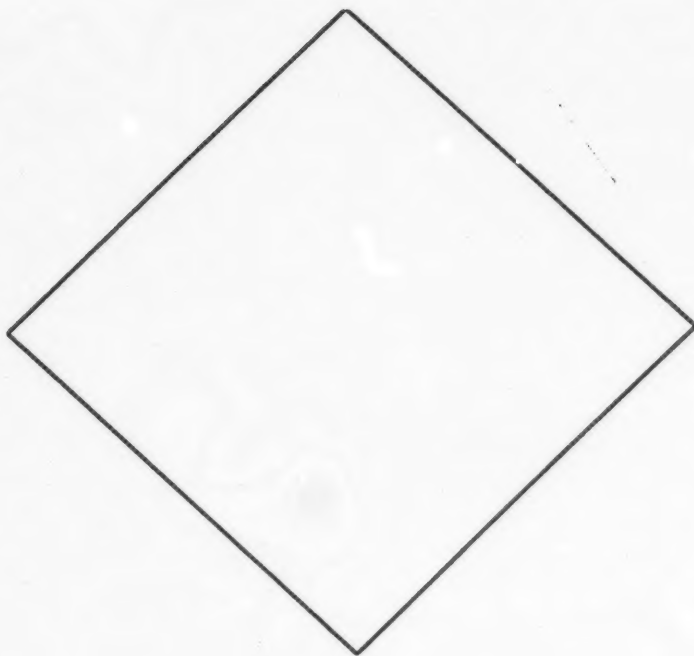
Select the location in the shape below that you believe others are next most likely select by drawing a number "3".



Select the location in the shape below that you believe others are *most* likely to select by marking a small x (about the size of this type) in the selected location.

Select the location in the shape below that you believe others are next most likely select by drawing a number "2".

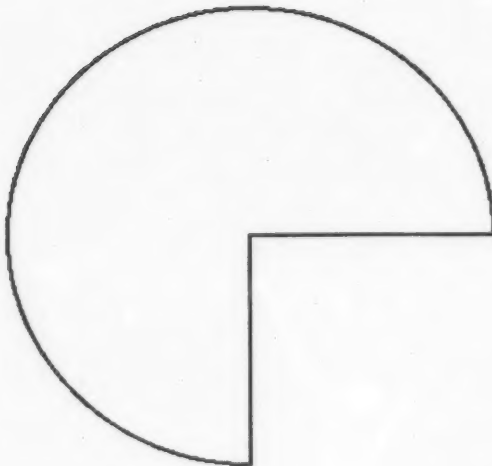
Select the location in the shape below that you believe others are next most likely select by drawing a number "3".



Select the location in the shape below that you believe others are *most* likely to select by marking a small x (about the size of this type) in the selected location.

Select the location in the shape below that you believe others are next most likely select by drawing a number "2".

Select the location in the shape below that you believe others are next most likely select by drawing a number "3".



Select the location in the shape below that you believe others are *least* likely to select by marking a small x (about the size of this type) in the selected location.

Select the location in the shape below that you believe others are next least likely select by drawing a number "2".

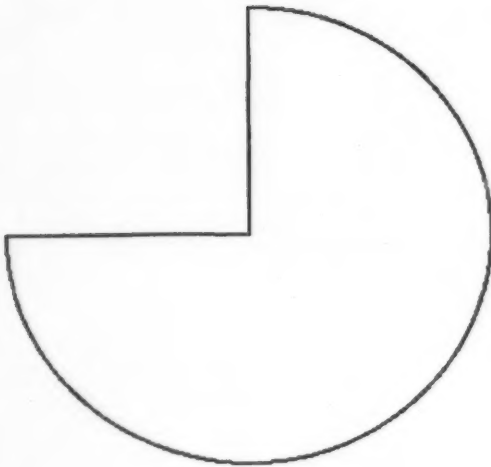
Select the location in the shape below that you believe others are next least likely select by drawing a number "3".



Select the location in the shape below that you believe others are *least* likely to select by marking a small x (about the size of this type) in the selected location.

Select the location in the shape below that you believe others are next least likely select by drawing a number "2".

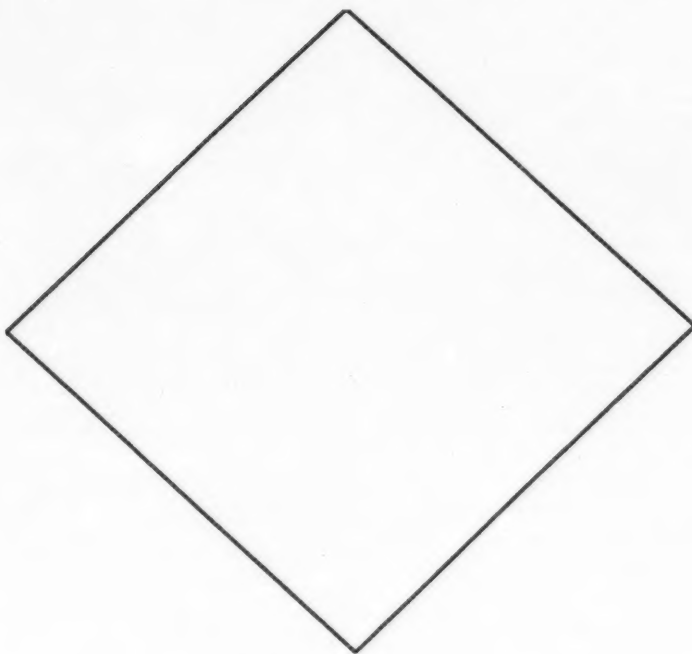
Select the location in the shape below that you believe others are next least likely select by drawing a number "3".



Select the location in the shape below that you believe others are *least* likely to select by marking a small x (about the size of this type) in the selected location.

Select the location in the shape below that you believe others are next least likely select by drawing a number "2".

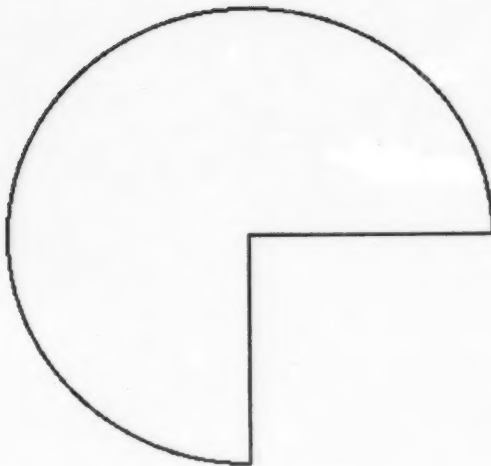
Select the location in the shape below that you believe others are next least likely select by drawing a number "3".



Select the location in the shape below that you believe others are *least* likely to select by marking a small x (about the size of this type) in the selected location.

Select the location in the shape below that you believe others are next least likely select by drawing a number "2".

Select the location in the shape below that you believe others are next least likely select by drawing a number "3".



The following information is required to complete the experiment. Please do not place your name, address, student ID, or any other information that can directly identify you on this questionnaire. Check off the answer that best describes you.

What is your gender?

male ☐

female ☐

Are you right or left handed?

right ☐

left ☐

Which age range matches yours? Specify on the last line if you wish.

<12 ☐

12-18 ☐

19-25 ☐

26-35 ☐

36-45 ☐

46-55 ☐

56-65 ☐

66-75 ☐

>75 ☐

specify _____

What education level have you completed?

grade school or less ☐

some high school ☐

high school ☐

business / trade school ☐

some college/university ☐

associate degree ☐

bachelors ☐

some graduate or professional ☐

graduate or professional degree ☐

What is your first language? _____

For the rest of the questions please check off the region that most closely matches AND specify the country.

What region were you born in?

Europe -
Asia -
Africa -
Canada/USA -
The Americas outside Canada/USA -
Other -
specify _____

Where did you live for the longest time prior to 18 years of age?

Europe -
Asia -
Africa -
Canada/USA -
The Americas outside Canada/USA -
Other -
specify _____

Where do you live now?

Europe -
Asia -
Africa -
Canada/USA -
The Americas outside Canada/USA -
Other -
specify _____

How would you describe your ethnic background? By that we mean where did your ancestors come from?

European -
Asian -
African -
American Aboriginal -
Other -
specify _____

Appendix 3
Internet Report

Report on Using the Internet in the Study Entitled
"Exploring the non-randomness of human spatial choice behavior:
Generating a database for tactical AI"

by
John Christie

Introduction

Collecting data and recruiting participants for experiments can often be one of the most time consuming and expensive components of research with humans. If the costs can be mitigated in some way and the burden of subject recruitment be removed from the researcher then the scientist is freed up to do more experimental design, data analysis and writing. Furthermore, if the cost of data collection is reduced the scientist may be able hire more staff and get more work done in general.

As an attempt to explore practical components of internet data collection, part of the data collection in a recent report by Christie & Klein (2000) was done on the internet. During the course of the experiment about 50% of the data were collected from internet volunteers. A very large number of participants were required for the study and this method was used to augment conventional data collection. It was also believed that collecting internet participants might be less expensive than conventional participants. With internet data collection most of the cost is up front and since the data is digitized through the whole process of data organization for analysis might be able to be automated.

We are by no means endorsing that experimenters fall into the trap of behaviourists many years ago where they just stick an animal in a box and let the equipment handle running the subject (this still happens sometimes). That turned out to be a real problem in some instances because experimenters stopped observing the behaviour of the subjects and missed many inferences. However, when large samples are required it only makes sense to observe a subset of the population. In the present study half of the participants were actually run in person by the experimenters so this was not an issue. But, in an experiment where the goal was to collect all of the data on the internet there should still be some effort made to run some participants in person. If the experimenter doesn't actually observe the entire session they can at least converse with the participant about the experience afterward.

Method

Participant Recruitment

The internet recruitment was done through several channels. Firstly, the more immediate groups that might be amenable to participating were contacted through email. Electronic mailing lists were used. This included faculty, students, and staff at Dalhousie University, and the staff at DCIEM. The next step was to list the experiment with all of the major internet search engines. A program called "Dump Truck" was used for this purpose. After this was completed a search was performed for internet sites that might specifically make note of psychology experiments and ask if they would post information for recruiting participants. There was only one found of a general nature, but that site was not very swift in responding to our request to be on their site and during the period of the experiment our project was never posted. Most of the internet sites relating to this are for the University at which they are hosted and do not post, or are reluctant to post, information about experiments from other locations.

Finally, postings were made on usenet. Rather than making mass postings across a large group of usenet groups at once individual postings were made in individual usenet groups. This was done to help prevent the appearance of "spamming" the net.

Technical Method Details

The internet experiment was served on a Sparc 5 computer connected up through 10baseT ethernet to Dalhousie's 30Mbit pipe to the internet. The initial pages of information and consent forms were done in standard HTML. The application to present the letter shapes and respond to the questions was done in Java and served as an applet. A data file was constructed after this was completed and immediately sent back to the server. This ensured that even if a participant failed to fill out the demographic questionnaire we would still have their selection data. The form at the end of the experiment was constructed with a Perl script.

Results

The results are presented in contrast with the data that was collected in the conventional fashion at the University. The first comparison that we have looked at is cost. In Table 1 these are presented in terms of hours and product required. In the University costs are dramatically different from other environments. The cost of obtaining participants or hiring programmers can vary significantly. We have presented the costs in the present fashion so that someone can apply them to their own costs structures. For our purposes the internet experiment was much cheaper. But, if we had to pay a programmer what they were worth (instead of getting students) and required fewer participants then our costs may have varied dramatically.

Table 1. Cost comparison between internet and paper versions of the experiment in resources. Actual monetary costs in industry will vary significantly as compared to University. Server time may be piggy backed on other costs while participants may actually have to be paid for their time in the experiment.

	Paper	Internet
Development	7 hours questionnaire development (done by the experimenter)	Paper preparation + 30 hours Java programming and Perl script development
Participant Recruitment	80 hours recruiting participants at the University	4 hours sending out notices to search engines, usenet, and mailing lists
Data collection and entering	240 hours of hand entering data and running participants	3 months of internet access time on a server with low speed requirements

Demographics of the kinds of participants collected in each version of the experiment were also examined. These are presented in Table 2. These differed tremendously. However, one must note that a University population is not a random sample and it is unclear how the internet population deviates from a random sample. Contrary to expectations, the internet population was balanced in both age and gender representation with proportions that approximate the population. This was not the case for the paper and pencil participants.

There was a large percentage of highly educated individuals in the internet population. However, this may be attributable to the fact that both faculty at Dalhousie University, and staff at DCIEM were strongly encouraged to participate in the experiment.

Data analyses of the distributions of performance yielded no significant differences once demographic problems were compensated for. We already knew that there were effects of gender and it is apparent from Table 2 that there is a significantly higher proportion of females in the paper version than the web version. Therefore, any differences we may find between the web and paper versions may only be due to gender. Given that there is a paucity of males in one of the groups it was thought that the best way to compensate for this in comparisons between the web and paper versions was to only compare the females. When only females are compared there were no differences.

Table 2. Frequencies and proportions of demographic measurements separated by whether the participant was in the internet or paper version of the experiment.

Gender	Internet freq.	Prop.	Paper freq.	Prop.
Male	108	0.52	93	0.31
female	101	0.48	203	0.69
Handedness				
Right	185	0.89	258	0.88
Left	23	0.11	35	0.12
Age				
<12	1	0.00	2	0.01
12-18	7	0.03	61	0.21
19-25	38	0.19	191	0.65
26-35	53	0.26	33	0.11
36-45	56	0.28	9	0.03
46-55	36	0.18	0	0.00
56-65	7	0.03	0	0.00
66-75	3	0.01	0	0.01
>75	0	0.00	0	0.00
Education				
Grade or less	1	0.00	22	0.07
Some high school	7	0.03	15	0.05
High school	21	0.10	13	0.04
Business/trade	8	0.04	3	0.01
Some college/univ.	40	0.19	199	0.67
Associate degree	4	0.02	1	0.00
Bachelors	34	0.16	24	0.08
Some grad. or prof.	21	0.10	15	0.05
Graduate or prof.	73	0.35	4	0.01
First Language				
English	162	0.78	282	7.33
Not English	47	0.22	14	5.00
Blank	41	0.20	1	4.33
Ethnic Background				
European	185	0.89	256	0.91
Asian	10	0.05	15	0.05
African	3	0.01	3	0.01
American Aboriginal	2	0.01	7	0.03
Other	7	0.03	2	0.01

Discussion

It was significantly less expensive to collect data on the internet in this experiment. Furthermore, in general, the demographics of the population collected on the internet conformed more closely to what would be expected in a true random sample than that collected using paper and pencil. But, this was confounded because a University student population was primarily used for the paper and pencil data collection. High education individuals were over represented in the internet data. This may have had to do with the email lists used on campus and the emails distributed at DCIEM alerting people about the internet experiment going to a large population of highly educated individuals.

We would recommend data collection on the internet for instances where the sample size must be large, and the development costs are not prohibitively higher than a non internet version of the experiment.

The only concern may be our relatively low N. After a couple of months we still had only 250 participants. But, one must keep in mind that by and large these participants are comprised of strict volunteers. If there were a way to design the experiment such that it contained an inherent reward then perhaps far more participants could be collected. A game might be an excellent way to do this.

DOCUMENT CONTROL DATA SHEET		
1a PERFORMING AGENCY John Christie, Dalhousie University, Halifax, Nova Scotia, Canada B3H 3J5		2 SECURITY CLASSIFICATION UNCLASSIFIED
1b PUBLISHING AGENCY DCIEM		
3 TITLE (U) Exploring the Non-Randomness of Human Spatial Choice Behavior: Generating a Database for Tactical AI		
4 AUTHORS Christie, John		
5 DATE OF PUBLICATION September 12, 2000		6 NO OF PAGES 93
7 DESCRIPTIVE NOTES		
8 SPONSORING/MONITORING/CONTRACTING/TASKING AGENCY Sponsoring Agency Monitoring Agency Contracting Agency DCIEM Tasking Agency		
9 ORIGINATORS DOCUMENT NUMBER Contract Report 2000-099	10 CONTRACT GRANT AND/OR PROJECT NO W7711-9-7580	11 OTHER DOCUMENT NOS
12. DOCUMENT RELEASABILITY Unlimited distribution		
13 DOCUMENT ANNOUNCEMENT Unlimited		

14 ABSTRACT

(U) It has been determined in basic psychological research that humans have preferences for certain numbers, sequences, and locations. In the current study we examine whether people understand this preference information, either explicitly or implicitly. 547 participants were presented with 4 shapes (approximately half of the sample completed the study on paper, the other half via the internet). For each shape they were asked to select 1. Any location within the shape, 2. The location you believe others are most likely to select, and 3. The location you believe others are least likely to select. Individuals were successful at predicting the locations others were likely to select, demonstrating an awareness of the nature of non-random behavior. However, individuals failed to accurately select the locations others were least likely to select. The applications of these findings are discussed.

Les recherches fondamentales en psychologie ont démontré que les êtres humains accordent la préférence à certains chiffres, à certaines séquences et à certains emplacements. Dans cette étude, nous cherchons à savoir si les gens comprennent ces renseignements sur les préférences, de manière explicite ou implicite. On a présenté quatre figures à 547 participants (environ la moitié des répondants ont indiqué leurs choix sur papier et l'autre par le biais d'Internet). Pour chacune des formes, on leur a demandé de choisir 1. n'importe quel emplacement dans la figure, 2. l'emplacement qu'ils pensaient que les autres seraient le plus portés à choisir.

et 3 l'emplacement qu'ils pensaient que les autres seraient le moins portés à choisir. Les participants ont réussi à prévoir les emplacements que les autres seraient portés à choisir, ce qui montre qu'ils sont sensibles à la nature du comportement non aléatoire. Les participants n'ont toutefois pas réussi à prévoir les emplacements qui seraient le moins souvent choisis. On discute des applications de ces constatations.

15 KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) non-random behavior, spatial choice, human bases,

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